

Mobile Radio Technology

The journal of mobile communications technology



Mobile console system, p. 10

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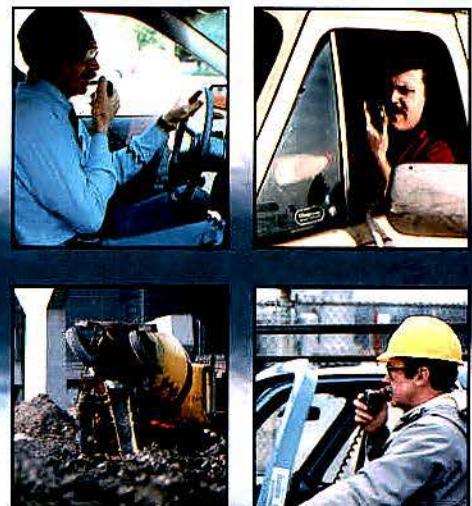
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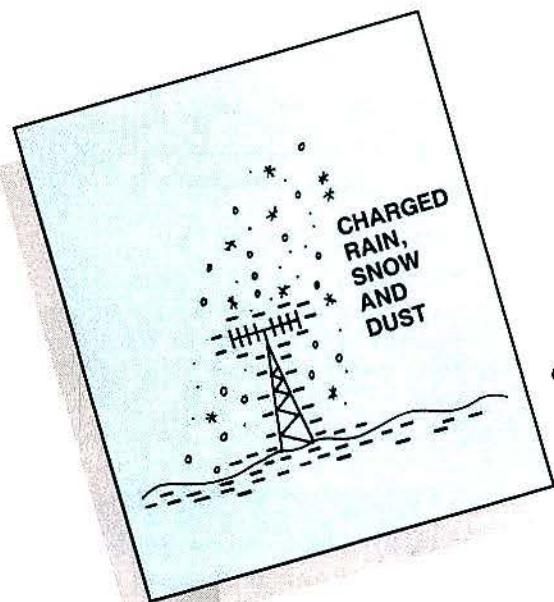
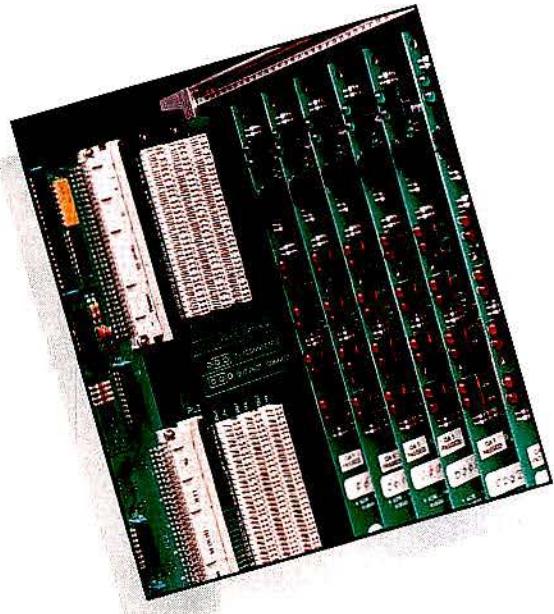
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features



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Frits P. Van Enk

Standard voice-frequency and data components combine with software and peripheral devices to offer a digitally controlled console system with expansion capacity and flexibility.

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Michael E. Norton

Adapted from aircraft applications, static discharger wicks for towers and antennas are designed to reduce radio noise caused by corona discharge and precipitation static. Improvements as great as 40dB have been noted.

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A.O.J. Woodfield

Wide-area radio communications system coverage can be achieved with multiple sites linked into a network. Here are some considerations for choosing between half-duplex and full-duplex configurations.

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1993 events.

On the cover: Jackson Wyatt, operations controls supervisor (left) and David Pagan, an assistant, in the Port Authority of New York and New Jersey's World Trade Center operations control center ("Seven-seven desk"), New York.

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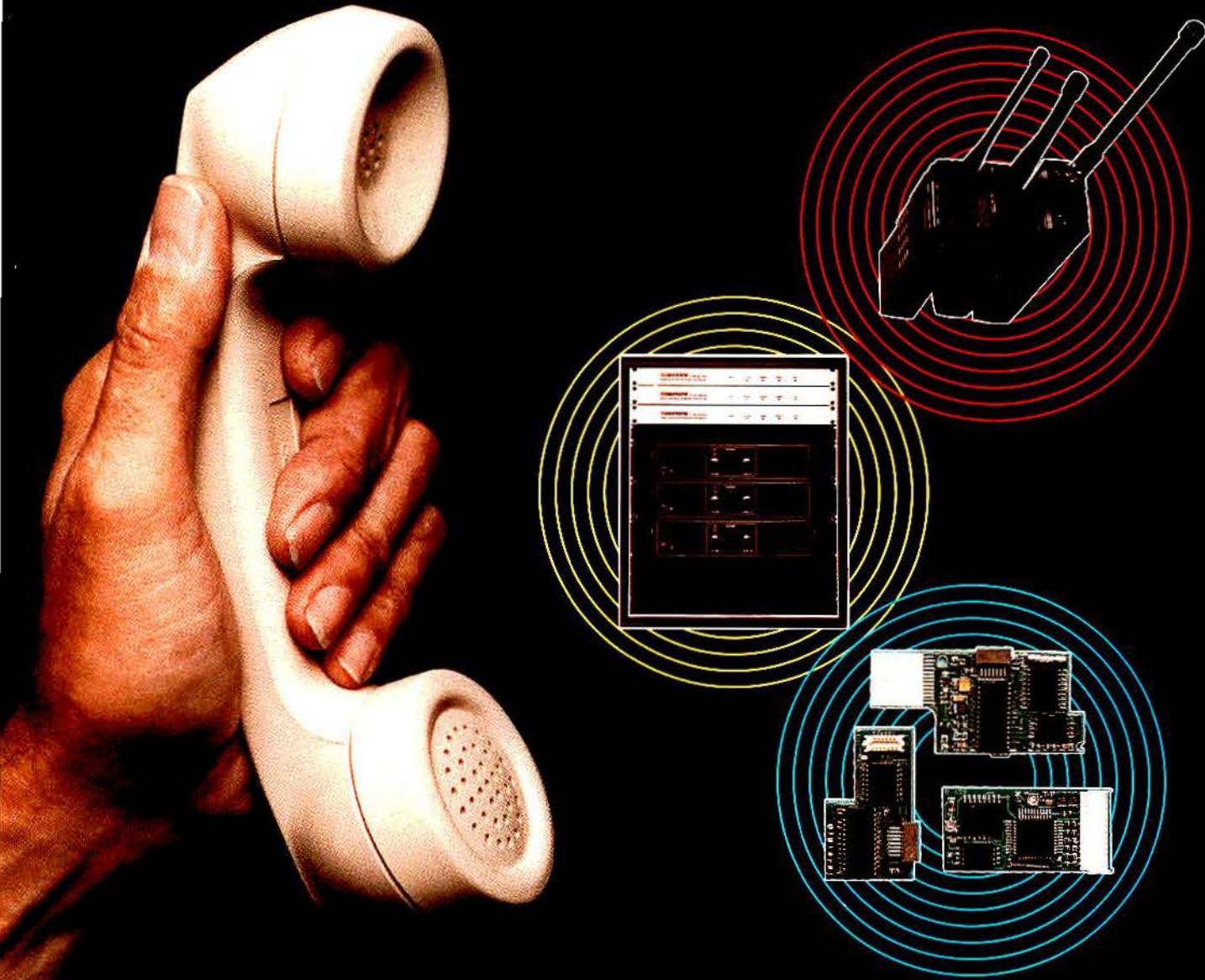
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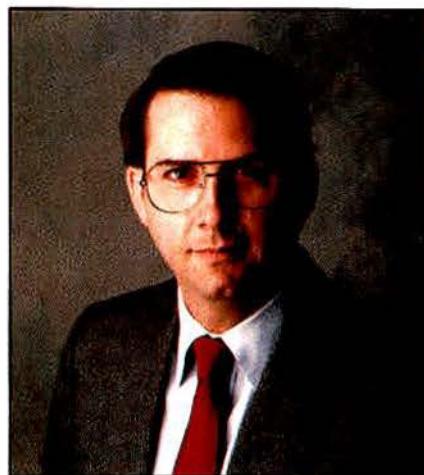
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Scanning . . .



SMR industry changes

The face of the specialized mobile radio (SMR) industry may change rapidly if the FCC approves applications for expanded service by existing system operators.

The expansion plans include low-power, low-site digital systems with frequency reuse within large cities and high-power, high-site regional digital networks. Low-power, low-site digital systems first became known as ESMR systems, the name given by Fleet Call, Rutherford, NJ. *E* stands for *enhanced*.

Some of the applications include requests to place transmitters closer together than the rules allow, a process known as short-spacing. The FCC has been allowing short-spacing based on two procedures. Some operators favor one procedure over another, leading to a dispute among some of them.

To allow time to resolve the dispute, the FCC has *frozen* short-spacing applications that rely on the more liberal of the two procedures, meaning it will accept no more such applications for the time being. It will, nonetheless, process the applications it already has.

To give an example of how extensive some of the expansion plans are, Fleet Call has filed applications for more than 700 5-channel digital SMR sites located at least 25 miles from the center coordinates for an 800MHz waiting list area.

Transit is asking for 233 800MHz SMR transmitter sites in 12 states,

using all of the frequencies for which it currently is licensed in Atlanta and that can be reused at the new site on a non-short-spaced basis.

Some operators are filing applications to expand their service area, to protect their existing service area or both.

What results from these new business tactics depends on what the FCC decides about the applications. If a sizable number are granted, the face of the SMR industry at the end of 1993 will be considerably different from its face as the year begins.

* * *

220MHz: waiting, waiting . . .

The 220MHz-222MHz band has been silent for more than a year, waiting for its new occupants, private radio users, to arrive.

As it stands, the FCC has conducted a lottery to assign construction permits to license applicants for local channels. Applicants for nationwide channels have to wait because the commission is reconsidering whether to assign them by lottery.

How fast the local licenses are going to be issued remains to be seen.

At present, only one manufacturer, SEA, Mountlake Terrace, WA, is known to offer FCC type-accepted 220MHz equipment.

Maybe, by the time you read this, the first permits will have been issued. And maybe not. Truly, the matter of 220MHz licenses is a waiting game.

* * *

Social event

The Radio Club of America's awards banquet has become the land mobile radio industry's social event of the year.

November 1992's banquet at the

New York Athletic Club drew an overflow attendance that included the most well-known land mobile radio industry personalities, along with figures from the broadcasting industry and amateur radio hobby.

Interest in the Radio Club is growing for a number of reasons, including the opportunity for like-minded people to get to know one another and to continue established friendships during a day's socializing before the banquet.

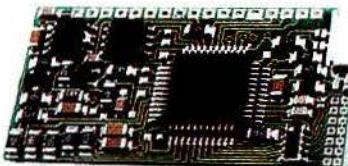
An afternoon program of talks on communications and broadcasting topics and the evening's speeches and awards presentations combine with the social aspects to make the annual meeting an event that many members and guests attend year after year.

One more reason for extra interest in the most recent banquet is that Fred M. Link's nearly 25-year tenure as club president was set to end the month after the banquet. Fred, who is our magazine's industry consultant and a focal point for the land mobile radio industry because of his extensive manufacturing background, consulting work and support of trade associations, has become the club's president emeritus.

—Don Bishop

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25-26—AMTEX, the American Mobile Telecommunications Association's Marketing and Technology Conference and Exposition, Sheraton, New Orleans. Contact: 202-331-7773.

March

2-4—Cellular Telecommunications Industry Association Winter Meeting and Exposition, Dallas Convention Center, Dallas. Contact: 202-785-0081.

17-19—Western States Regional Conference Associated Public-Safety Communications Officers Meeting, Hyatt Regency, Phoenix. Contact: Deborah L. Overton, 602-256-1029.

21-24—Energy Telecommunications and Electrical Association, New Orleans Convention Center, New Orleans. Contact: 214-235-0655.

23-25—International Mobile Communications Expo/Spring, Anaheim Convention Center, Anaheim, CA. Contact: 303-220-0600.

April

19-22—Supercomm and Telocator Wireless Conference, Georgia World Congress Center, Atlanta. Contact: 800-326-8638.

21-23—North Central Regional Conference Associated Public-Safety Communications Officers Meeting, Radisson Inn Bismarck, Bismarck, ND. Contact: Lyle V. Gallagher, 701-224-2127.

May

12-14—Annual Mobile Communications Conference, sponsored by the National Association of Business and Educational Radio (NABER), Hyatt Regency Hotel, San Antonio. Contact: 800-759-0300.

16-19—East Coast Regional Conference Associated Public-Safety Communications Officers Meeting, Cavalier Hotel, Virginia Beach, VA. Contact: Bill Marriott, 804-247-8431.

18-20—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Meadowlands Hilton, Secaucus, NJ. Contact: George D. Graul, 908-290-1128; fax 908-290-1932.

26-28—RadioComm, Metro Toronto Convention Centre, Toronto. Contact: Lisa La Prairie, 613-233-4888.

June

29-July 1—Utilities Telecommunications Council Annual Meeting, San Antonio Marriott Rivercenter and Convention Center, San Antonio. Contact: Rita Clark, 301-621-7802.

July

18-22—Forestry-Conservation Communications Association, Jackson, WY. Contact: Don Pfohl, 602-644-3166.

August

8-13—Associated Public-Safety Communications Officers 59th National Conference, New Orleans Convention Center, New Orleans. Contact: 800-824-1850.

September

21-23—International Mobile Communications Expo/Fall, Philadelphia Convention Center, Philadelphia. Contact: 303-220-0600.

28-Oct. 1—Mobile Communications Marketplace, New Orleans Convention Center, New Orleans. Contact: Telocator, 800-326-8638.

October

6-9—Industrial Telecommunications Association Annual Meeting, La Quinta Hotel, La Quinta, CA. Contact: Barbara J. Levermann, 703-528-5115.

12-13—SMR/Private Carrier Management Conference, Loews Coronado Hotel, San Diego, CA. Contact: 202-331-7773.

16-21—International Association of Chiefs of Police Annual Conference, Cervantes Convention Center, St. Louis, MO. Contact: 703-836-6767.

November

19—Radio Club of America Awards Banquet, New York Athletic Club, New York. Contact: 201-652-6811.



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The journal of mobile communications technology

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How do you spell VSWR?

By Harold Kinley, CET

Of course, there is only one way to spell VSWR, but there are many ways to represent antenna (or other RF load or source) mismatches using different

measuring units.

For example, occasionally you will see the terms *return loss*, *reflection coefficient*, *percent reflected power* and *reflected-to-forward power ratio*. It is enough to confuse Confucius!

But do not despair. There is a way to

convert among the various units without using calculus.

► **VSWR**—Probably the most widely used and best understood measuring unit used by radio communications technicians is voltage standing wave ratio (VSWR).

When a manufacturer specifies that a certain antenna operates over a certain frequency range at a VSWR of 1.5:1 or better (less), we immediately know that this is a good match—the system will operate efficiently with minimal wasted power.

► **Return loss**—When the forward power on a transmission line equals 100W and the reflected power equals 25W, the return loss is determined by the following formula:

$$R_L$$

$$= 10 \log(P_F/P_R)$$

$$= 10 \log(100/25)$$

$$= 10 \log(4)$$

$$= 10 \times 0.602$$

$$= 6.02 \text{ dB}$$

where

R_L = return loss in decibels

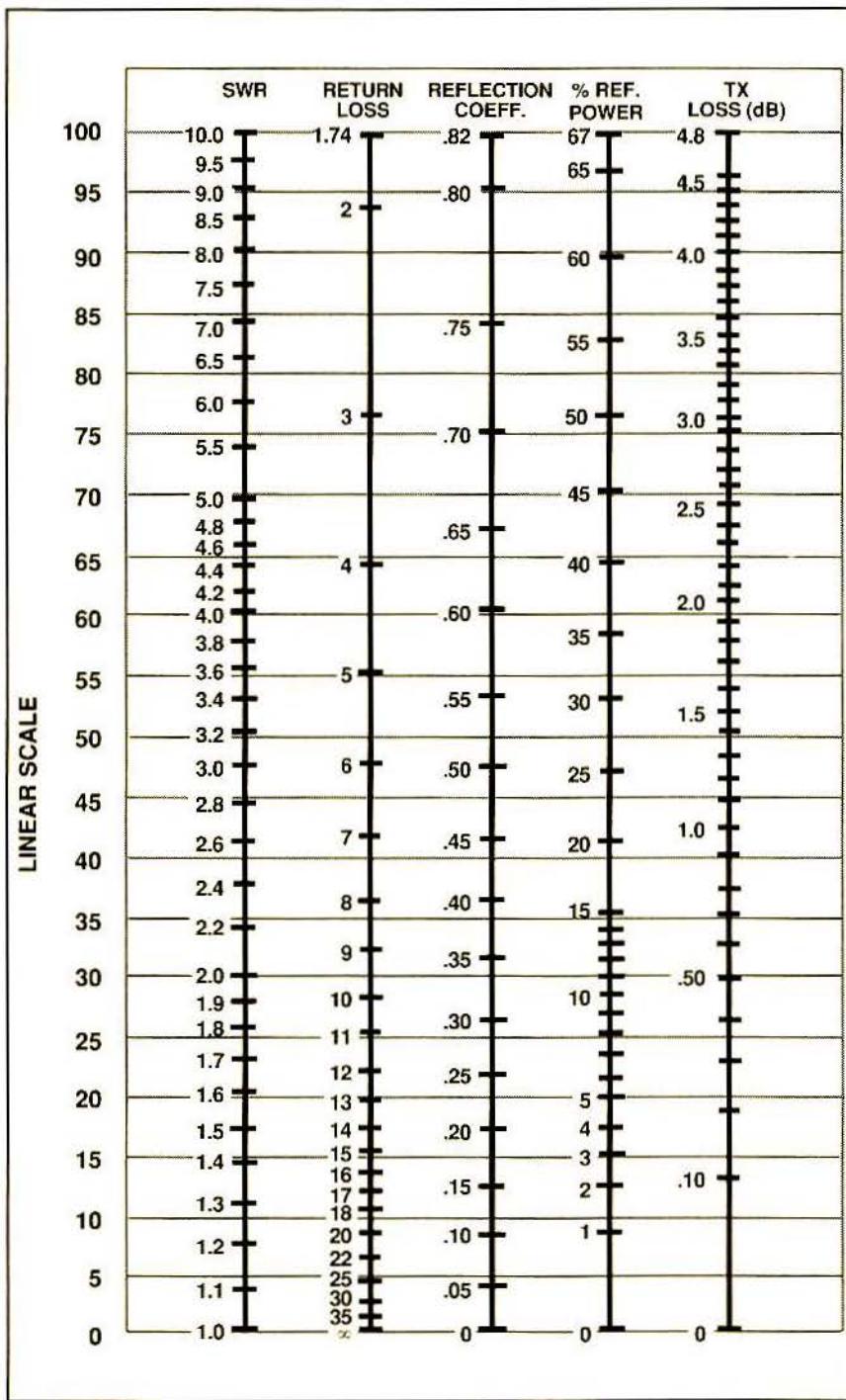
P_F = forward power in watts

P_R = reflected power in watts

Because of transmission line loss, the VSWR at the antenna is worse than what is measured at the transmitter, and the same difference applies for every unit of measure.

It is easy to convert return loss at the transmitter to return loss at the antenna because the transmission line loss usually is stated in terms of decibels per 100 feet (dB/100ft.).

For example, if the line loss is 2dB and the return loss at the transmitter is (continued on page 58)



Kinley is a certified electronics technician with the South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, Prentice-Hall, 1985.

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Power When You Need It.

Base console system uses digital control

Standard voice-frequency and data components combine with software and peripheral devices to offer a digitally controlled console system with expansion capacity and flexibility.

By Frits P. Van Enk

The days when mobile systems consisted of a base station with a rooftop antenna serving a single-digit number

Van Enk is engineering manager at GPT - Sepac Pty. Limited, a radio communications system company based in Springvale, Victoria, Australia.

of mobiles on a single channel (a "base and six" system, for example) are behind us. Instead, a range of modern techniques and system features are available to support a far more effective system design.

Modern frequency synthesizer and process control technology allow the design and manufacture of complex, yet economical, mobile radio transceivers.

Trunking technology offers wide-area coverage. Selective calling and data transmission improve communications speed and quality. Access to the public switched telephone network (PSTN) is readily available.

Cellular telephone base station control system technology generally has been in the forefront of mobile radio developments. At the same time, private mobile radio system base station control technology generally has been lacking. Several factors contribute to the situation.

► Base control systems usually last longer than mobile units.

► Mobile fleet expansion and improvement are relatively simple, but many base control systems are inflexible and difficult to expand.

Large systems, such as those used by police agencies, fire departments and ambulance services, have suffered because most base control systems have been increasingly complex, inflexible and unreliable. Thus, overall system performance may be limited by weaknesses in base control equipment that cannot take full advantage of powerful features and capabilities offered by modern mobile radios. The use of a digitally controlled console system (DCCS) with universal hardware and software elements makes it easier and more economical to make custom base controls to meet individual system requirements. (Because the DCCS is compatible with common RF base station technology, RF system components are not described in this article.)

Abbreviations

DCCS—digitally controlled console system.

PSTN—public switched telephone network.

E/M—input/output. Literally "ear/mouth," E/M is derived from telephony: ear (input to device); mouth (output from device).

DVSU—digital voice switching unit.

CPU—central processing unit.

codec—coder-decoder.

CCIR—International Radio Consultative Committee.

EEA—Electronics Engineering Association (U.K.).

EIA—Electronic Industries Association.

ZVEI—Zentralverband der Electrotechnischen Industrie (Germany).

PABX—private automatic branch exchange.

VSWR—voltage standing wave ratio.

PA—power amplifier.

RF—radio frequency.

PCM—pulse code modulation.

PC—personal computer

AT—Advanced Technology (an IBM trademark).

selcal—selective calling.

System concept

Rather than being designed for a spe-

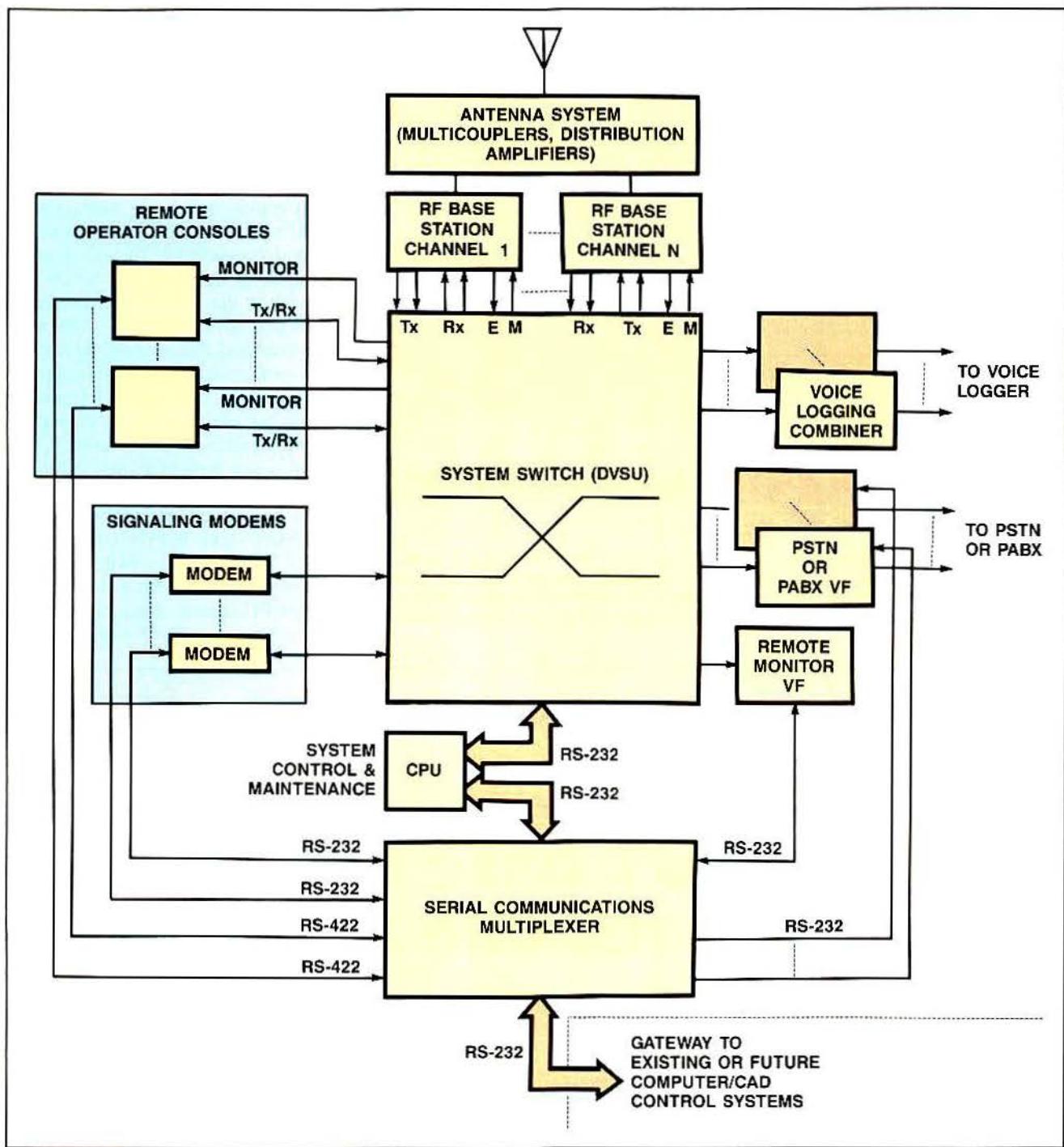


Figure 1. A block diagram of a multichannel, multioperator private mobile radio digitally controlled console system shows its principle elements.

specific application, the DCCS was conceived as a universal answer to all base control system requirements. First, a general base control system model was identified. Second, individual functions were analyzed and defined. Third, individual building blocks were designed and developed. The result is a DCCS

that is flexible, universal and expandable at any stage to provide additional capacity, new functions such as data communications, connection to new or existing computer-based management systems or a combination.

Figure 1 above shows the principle elements generally found in a multichan-

nel, multioperator private mobile radio DCCS.

► *Antenna and base radio system*—The DCCS is RF transparent. It works with all radio equipment, and it does not depend on a particular make or model of base stations. The DCCS typically connects at the four-wire level with E/M

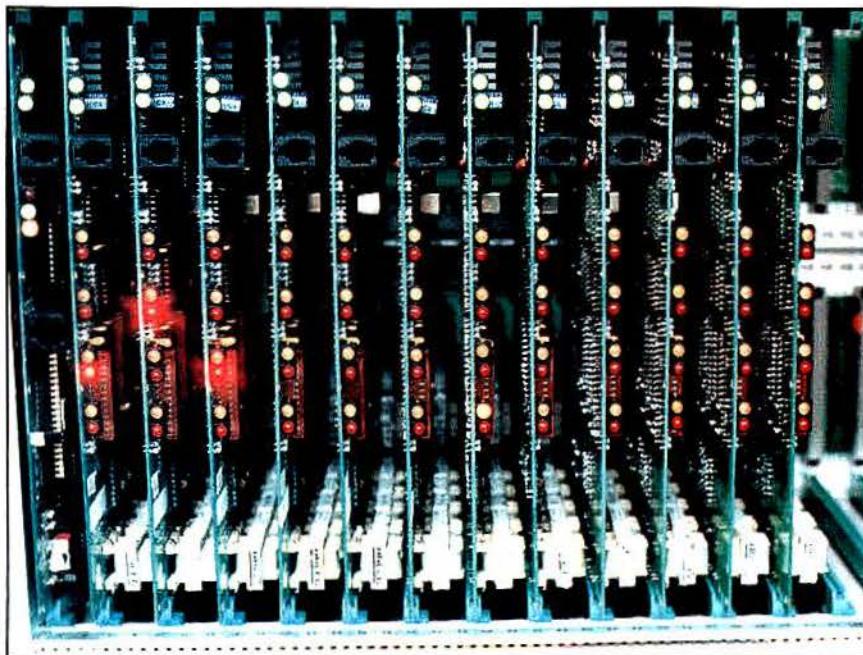


Photo 1. The digital voice switching unit, a stand-alone 19-inch rack module, contains a CPU card (first card from the left) and as many as 16 line cards per card cage. Twelve cards actually are fitted. Each line card provides four four-wire E/M ports. Cards are fitted with several single-point light-emitting diode (LED) indicators to visually indicate unit status.

signaling. (The E lead indicates a carrier is being received. The M lead controls the base station transmitter.) A four-wire connection is not essential. A two-wire connection is possible, but a four-wire connection enables facilities such as channel-patching and talk-through control.

► **Central switch**—A base control system's primary function is to connect any peripheral device, such as an operator console, data terminal, PSTN line and others, via any base station channel to any mobile user. The communication channel thus established may be of an analog nature (voice, for example) or may carry data information (selective calling and digital data, for example).

Voice band switching is handled by a digital voice switching unit (DVSU), which forms the central switch. (See Photo 1 to the left.) The DCCS central processing unit (CPU) controls the DVSU. The DVSU can switch any port to another port or combination of ports under CPU control. Input/output ports universally are four-wire plus E/M.



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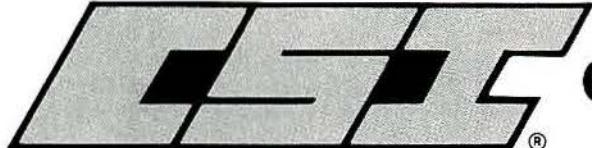
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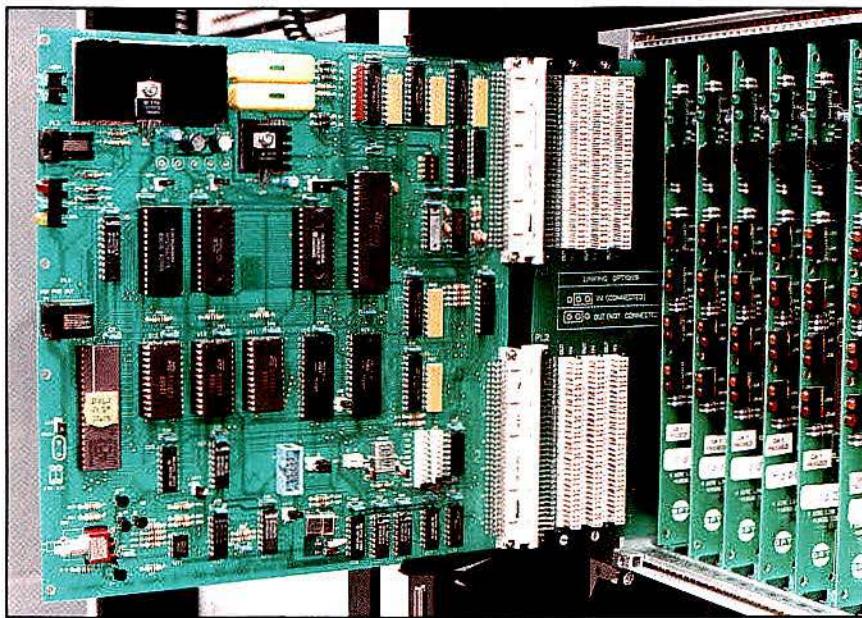


Photo 2. A serial communications multiplexer (SCM) card frame holds six 'slave cards' fitted inside the rack and the SCM controller card fitted on an extender module for service and checking purposes.

The DVSU uses digital switching. Each input/output port is fitted with a codec that converts voice-frequency signals into a 124kbps (kilobits per second) pulse-code modulation (PCM) format. The converted voice-frequency signals

are fed to the DVSU PCM bus.

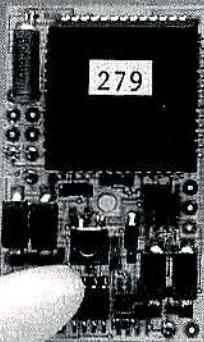
A DVSU consists of a controller card that provides switching control and external RS-232 input/output functions, and a series of plug-in line cards. Each line card provides four four-wire voice circuits, each with a standard E/M signaling interface.

The DVSU controller card manages as many as 64 line cards or 256 audio circuits. As many as four conference bridges may be installed. Each bridge supports a range of capabilities from one conference of 32 parties to 10 conferences totaling 32 channels.

Digital switching technology offers superior crosstalk and signal-to-noise performance. The signal-to-noise ratio and crosstalk isolation typically exceed 70dB. Distortion is negligible.

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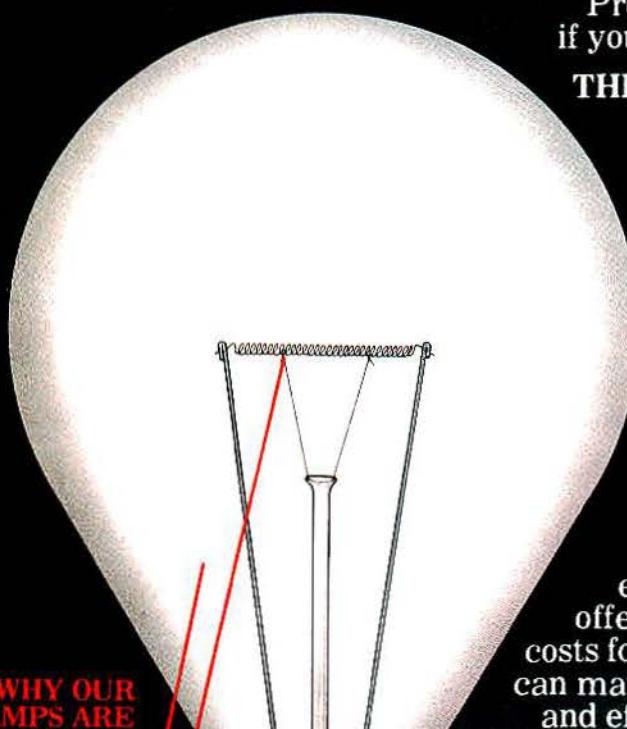
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Principle elements

The principle elements found in a multichannel, multioperator private mobile radio digitally controlled console system (DCCS):

- Antenna and base radio system elements.**
- Central switch (digital voice switching unit).**
- Digital system communication.**
- Serial communications multiplexer.**
- Operator consoles.**
- Scal and signaling modems.**
- PABX/PSTN interface.**

serial duplex data links.

This approach has advantages. It makes the system highly flexible because changes and enhancements can be implemented with software instead of hardware. Consoles may be built from

conventional audio and control hardware. Alternatively, the operator interface can be implemented using computer terminals. New peripherals can be added any time, with only some additional CPU software being required in many cases. Finally, computer-controlled data and control systems may be connected to the DCCS directly using a serial communications multiplexer.

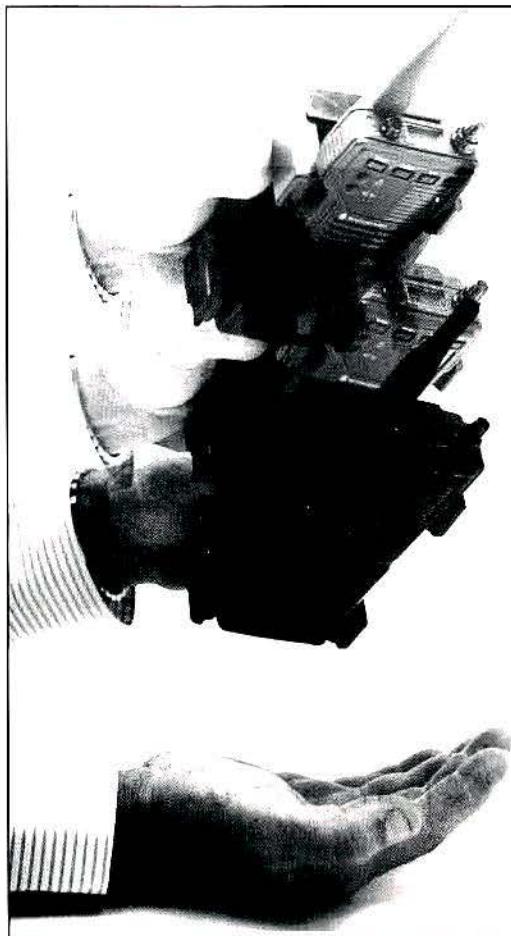
► **Serial communications multiplexer (SCM)**—It is not practical to connect serially controlled peripherals directly to a CPU. The number of computer serial ports usually is limited. Thus, a multiplexer is required.

The multiplexer must be intelligent because it must communicate with a variety of peripherals, each with specific communication protocols. In addition, it must store information in buffers for later interrogation and transfer to the CPU because the CPU operates on a time-sharing basis. The CPU is not available to any particular peripheral at any time.

The DCCS SCM is composed of a dedicated, processor-controlled CPU card that communicates with the system CPU via a high-speed data link. Also part of the multiplexer are the dedicated CPU card's associated SCM "slave cards," with which it communicates via a parallel high-speed data bus. Each slave card provides four serial ports. Each serial port can have its own unique communication protocol. Additional system capacity is obtained by plugging in more SCM cards. Slave cards are fitted either with an RS-232 interface or with an RS-422 interface to facilitate connecting peripherals via extended cable lengths. (See Photo 2 on page 14.)

Physically, the RS-232 and RS-422 slave cards are nearly identical. They use the same printed circuit board and overall electronic components.

► **Operator consoles**—The operator's audio facilities include a built-in speaker and telephone-type handset. A headset and boom-type microphone-and-PTT switch may be connected, too. An independent audio output channel pro-



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Keeping data on the move

vides monitoring of non-selected (non-operational) voice channels via an external speaker. (See Photo 3 to the right.)

A two-line-by-20-character liquid crystal display and a series of pushbuttons on a 3x4-button keyboard provide the operator interface.

The consoles are controlled serially, to the RS-232 standard, to allow the use of extended cables. The console software essentially is fixed because the actual console operation is set and configured in the CPU.

Consoles are fitted with an RS-232 port that may be connected to an optional screen-based terminal to provide extended display facilities if required.

For special applications, the console's RS-232 port may be connected to a personal computer to provide computer-based access to the system.

► *Central processing unit*—The CPU is a standard IBM-compatible AT PC fitted with two serial ports. One port connects to the serial communications multiplexer via a high-speed serial bus

(normally 19.2kbps). The other port connects to the digital voice switching unit serial control port.

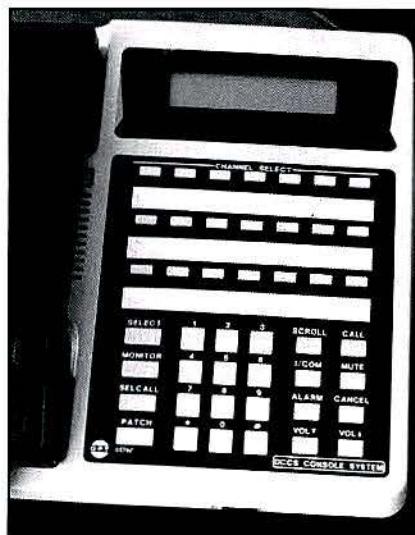


Photo 3. The DCCS console with handset has three rows of push-buttons under the display for channel and PABX line selection. The 3x4 keyboard dials the telephone and selective calling.

A keyboard and screen may be connected for system maintenance. They are not required for normal operation. (See Photo 4 to the right.)

Because it is modular, the CPU software allows quick and effective system customizing and configuring.

An optional system printer may be connected to further facilitate system maintenance.

► *Selcal and signaling modems*—To provide selective calling (selcal) or data facilities, signaling modems may be added to the system upon initial installation or later when the system is expanded and signal facilities may be required.

One such modem, a tone sequential selcal encoder-decoder, uses digital analysis to improve the signal-to-noise ratio, to reduce falsing to a minimum and to increase resistance to interference and distortion.¹ Digital decoding allows tone sequences as short as 20ms (milliseconds), resulting in a typical message time of 100ms for selcal sequence.

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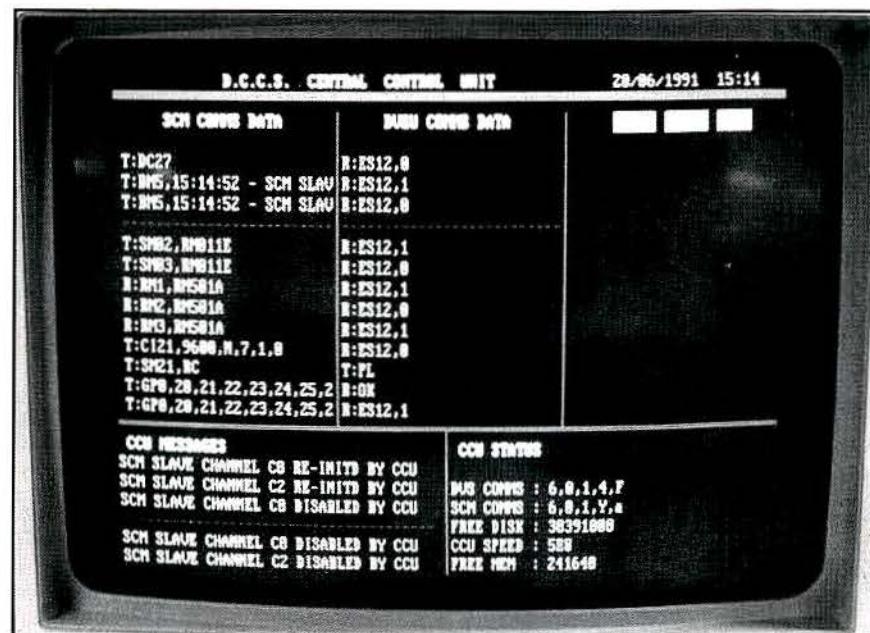


Photo 4. The DCCS video screen displays status and current configuration data. It has no operational function, being used only for system installation and maintenance.

The selcal modem can operate on a range of international tone sets, including CCIR, EEA, EIA and ZVEI stan-

dards. It handles tone periods from 20ms to 100ms. It is programmable to operate on any of the commonly used

sequence formats, including five-tone, five-tone/status and six-tone formats.

Finally, the modem has a non-predictive decoder that decodes any selcal number received, provided the sequence includes the correct tone set, period and format. It performs all front-end processing and reports correct decodes in RS-232 format to the CPU via a serial communications multiplexer slave port.

The modem transmits any new selcal messages as directed by the CPU. On-board buffering prevents new selcal encode commands from the CPU from aborting decodes in progress. Similarly, decoded sequences are buffered and reported to the CPU on command.

In turn, the CPU passes received selcal messages to the consoles for display, with other selcal processing data such as queueing, alarm response and status. The console operator may key in selcal sequences with the 3x4 keypad.

When digital data modems are used instead of selcal modems, the serial communications multiplexer may be

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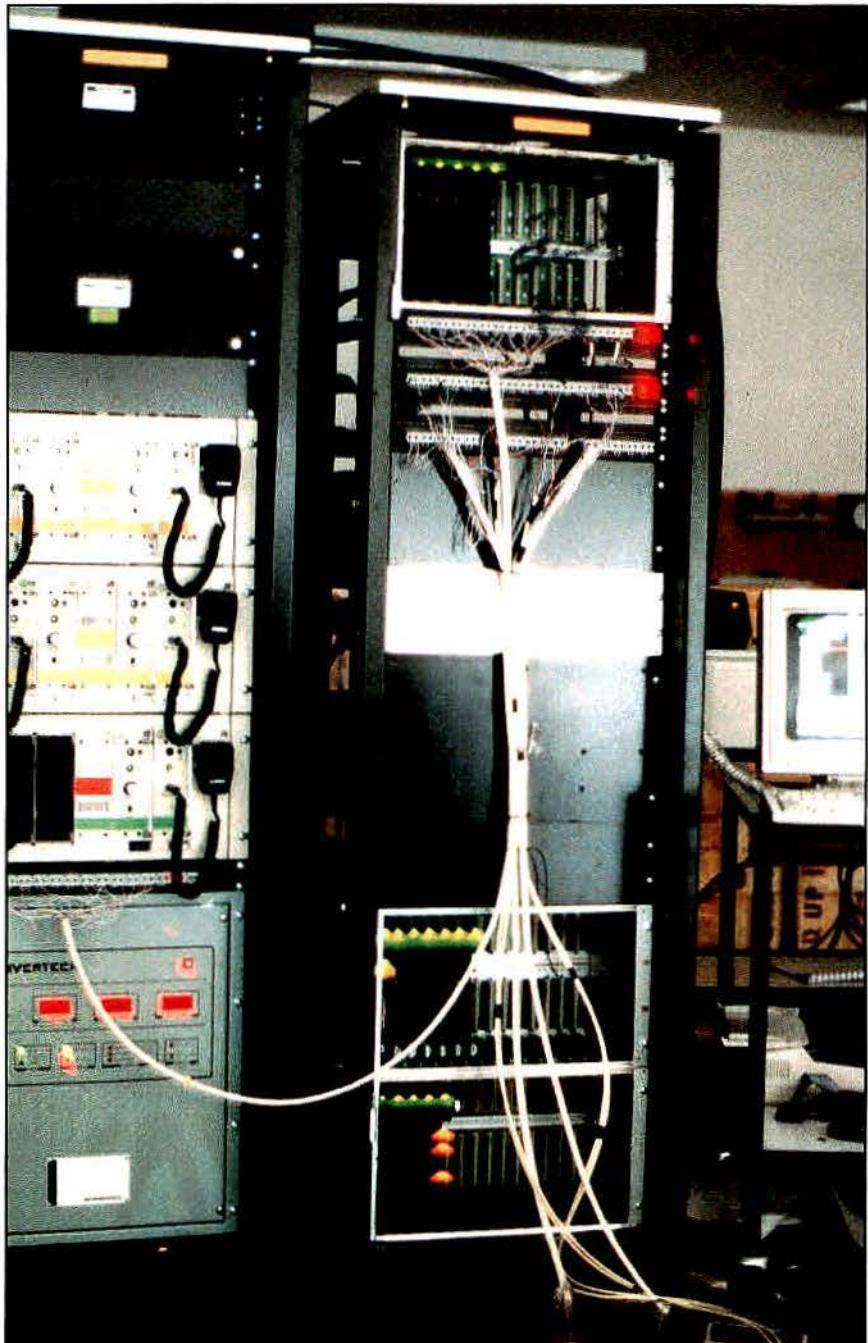


Photo 5. A typical digitally controlled console undergoes final testing at the Springvale, Victoria, factory. External cabling is temporary and is for factory testing only. The system provides for four operator consoles, multiple radio channels, selective calling, PABX/PSTN interconnection and remote monitoring. A voice logging recorder is installed, too. The rack on the left includes the radio equipment, such as links, multicouplers and the dc power supply.

connected directly to an existing database or computer-aided dispatch system via an SCM gateway port to extend the system with full digital signaling facilities.

The DCCS can be fitted with optional PABX/PSTN access via a standard

telephone interface peripheral device. This device handles line loop, ring detect and dial out functions. Its audio ports connect to the DVSU. Its serial control port connects to the CPU via an SCM slave port.

Console operators can set up calls into

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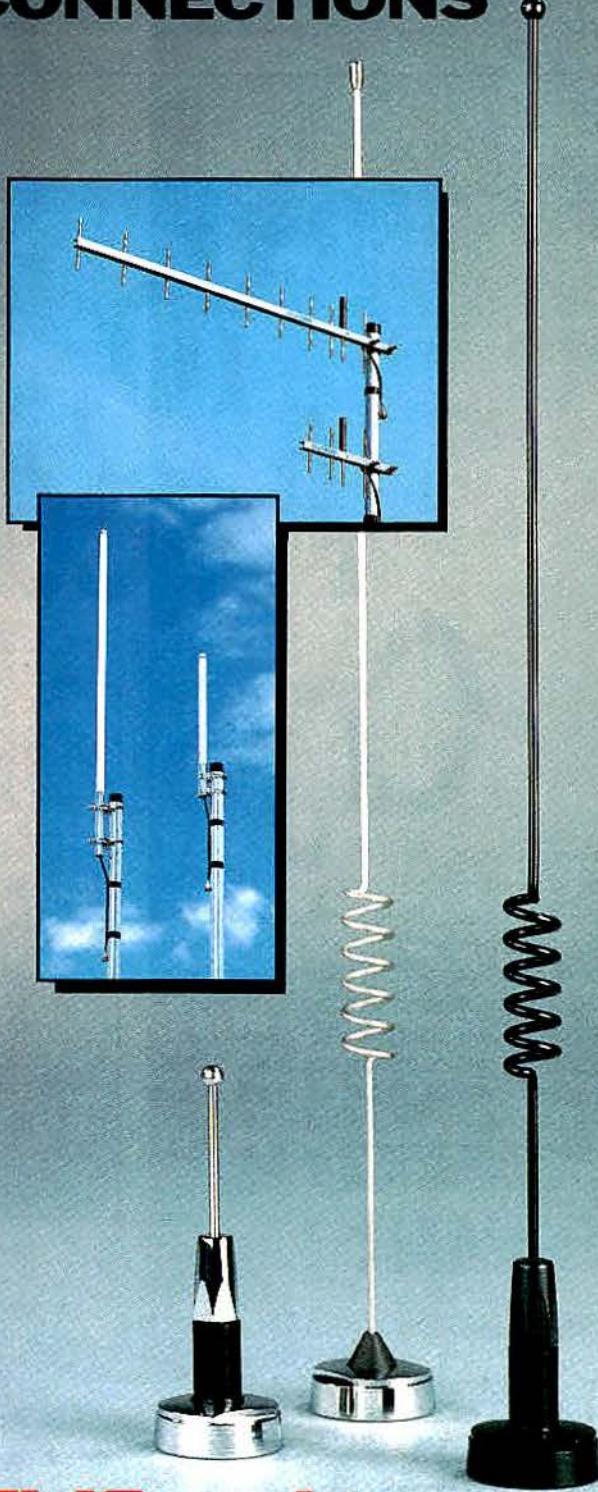
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the PABX or PSTN networks. When the console operator has PABX as one of the monitored channels, an incoming telephone call is reported to that console, alerting the operator that a call is waiting.

Console operators may connect incoming or outgoing calls manually to a mobile extension by using the patch facility. Alternatively, mobile phone calls

may be automatically placed and received, using CPU software and associated signaling modems to encode and decode mobile and remote subscriber identities.

Other peripherals

Several other standard peripherals are available to improve DCCS operation. A voice logging combiner combines

each 2x2 wire audio port into a single two-wire signal for logging by a recorder. Each combiner card has a capacity of four four-wire circuits.

A supervisory remote monitoring system may be overlaid on the whole radio system to report remote site status conditions, such as VSWR and RF PA output power.

The system's base decoder input connects to the DVSU. The decoder's serial data port connects to the CPU, which in turn directs supervisory messages and alarms to the consoles for display and operator response.

Other peripherals may be added to the system. The only compatibility requirement is the presence of standard 600Ω voice-frequency input/output ports and the availability of a suitable serial control port. Photo 5 on page 20 shows a typical implementation of a DCCS.

Conclusion

The DCCS base control system adheres to a basic philosophy of standard voice-frequency and data interface for its components to boost technical performance and allow the addition of new, existing, standard or proprietary peripherals.

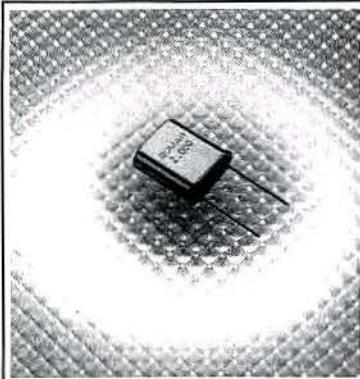
The mechanical implementation is based on the same principle, using standard 19-inch rack and Eurocard technology with cards plugging into standard motherboards to provide future expansion capacity.

These hardware elements, together with software technology, result in a systems technology that is flexible, economical and compatible with future enhancements and expansion.



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1. Van Enk, Frits P., "Five-Tone Sequential Boosts System Capabilities," *Mobile Radio Technology*, October 1988.

2. Van Enk, Frits P., "Minimum Requirements For CTCSS Signaling," *Mobile Radio Technology*, November 1987.

Although these back issues may be available at a library, they are unavailable from the publisher. Back issues of the last two years may be purchased from Intertec Publishing for \$5 each, postpaid. To order by telephone, call 913-967-1711. Mail orders go to Circulation Services, Intertec Publishing, P.O. Box 12901, Overland Park, KS 66282.

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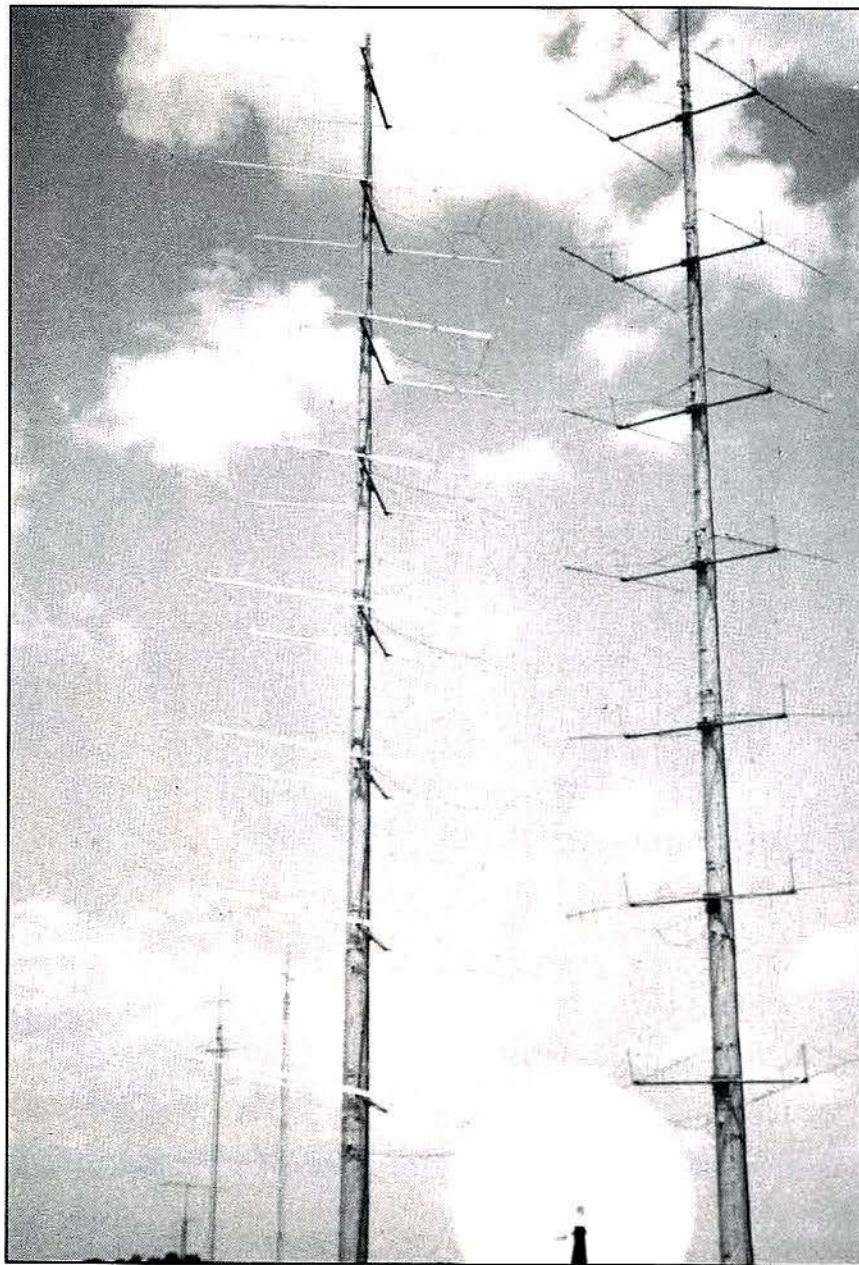
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Static discharger wicks cut precipitation static noise

Adapted from aircraft applications, static discharger wicks for towers and antennas are designed to reduce radio noise caused by corona discharge and precipitation static. Improvements as great as 40dB have been noted.



By Michael E. Norton

Have you ever wondered why a receiver's noise floor elevates above the ambient noise level and, more importantly, what can be done to reduce or eliminate the problem?

Modern receivers have high sensitivity and extend radio communications range under normal conditions. But electrostatic discharge (ESD) produces broadband noise that can degrade system performance by raising the noise floor.

In 1988, I began monitoring radio signals used for nationwide communications via meteor-burst propagation. The signals are slightly stronger than galactic noise. Daily monitoring revealed the true importance of noise. Noise level increases of only a few decibels can entirely mask weak signals. As noise increases, a high receiver signal-to-noise ratio can be swamped easily.

Noise "crashes" propagated from distant thunderstorms and noise from man-made electromagnetic interference must be tolerated. At least they usually come in the form of impulses. Such noise may be bothersome, but at least it is not normally sustained.

ESD noise, on the other hand, may continue for long periods.

Earth-ionosphere capacitor

Air, a mixture of gases, largely is composed of nitrogen and oxygen. Air

Norton is the owner of Static Busters, Elizabethtown, KY, 502-737-5082. He is a senior member of the Association of Communications Technicians, and he holds a NABER technician certificate.

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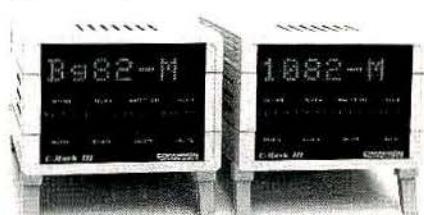
In the dispatch center, our C-Mark III series of two-way dispatch displays instantly convert numeric data fields and IDs to alpha numerics. Up until now, you could only get this type of aliasing with expensive C.A.D. units.

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The C-Mark III Series of two-way dispatch displays give you the functionality of expensive C.A.D. systems.

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*CDEU-1 encoder-decoder features
two-way handshaking protocol that
guarantees message reliability.*

generally is considered to be an insulator. It would be an excellent insulator if all its oxygen and nitrogen molecules were in a neutral state. But air is composed of varying quantities of neutral molecules and positive and negative ions—charged molecules.

As the number of ions in the air increases, air becomes a progressively better conductor. Generally, the higher the altitude, the more ions air contains. At an altitude of 40 miles to 50 miles, in a layer of the atmosphere called the ionosphere, ions are so plentiful they reflect radio waves.

Although the ionosphere is electrically conductive, as a whole it is considered to be "uncharged" because the layer's number of positive ions equals the number of negative ions and electrons. The ions and electrons are distributed within the ionosphere in layers of various altitudes and degrees of charge.

In contrast, the earth has surplus electrons. Its charge approximates 300,000V to 400,000V negative compared to the ionosphere.¹ This potential difference,

together with the atmosphere's total conductive qualities, is sufficient to cause the earth to lose electrons to the ionosphere continually.

The entire earth's surface and the ionosphere may be considered to be oppo-

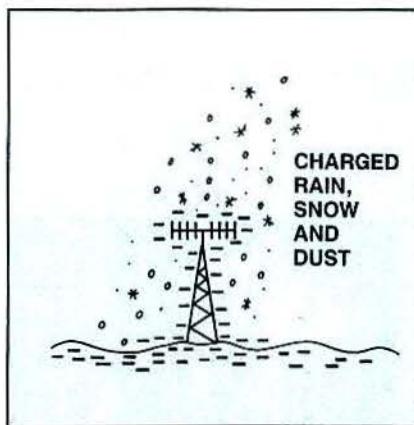


Figure 1. Electrically charged particles, such as raindrops, snow and dust, strike an antenna's tower, boom or elements and induce a current impulse that produces broadband noise. The noise is called *precipitation static*.

sitely charged plates of a vast capacitor with a leaky air dielectric. Along with ions that make the air slightly conductive, meteorological processes contribute to the earth-ionosphere "capacitor's" leakage. The hydrologic cycle—precipitation—falling rain, for example—tends to drop larger, less mobile ions toward the earth as electrons rise in moisture-laden updrafts.

The earth's steady loss of electrons is called *ionic current*. Infinitesimal as it is, it has been measured and it amounts to about $9\mu\text{A}$ for every square mile on the earth's surface.¹ Ionic current flows via the most convenient conductive path—the path of least resistance. Thus, most of the electrons are discharged at natural and man-made *points*, such as peaks, trees, buildings, towers and antennas that project into the air.

When electrically charged particles, such as raindrops, snow and dust, strike an antenna's tower, boom or elements, they induce a current impulse that produces broadband noise. (See Figure 1 to the left.) The noise is called *precipitation static*. It generally is defined to include all external atmospheric electrical effects that produce electromagnetic interference.

Corona discharge noise

Another type of noise, *corona discharge noise*, happens when electrons flow through the antenna's tower, boom or elements and into the atmosphere when a charged cloud is near. (See Figure 2 below.)



**Remote Control, of up to 16 Channels.
Radius M200 or Maxtrac 300 Series Radios.**

The CPI model MCR10 remote and MCR10P interface panel will allow you to remote control Radius or Maxtrac radios, up to sixteen channels, over any two wire voice grade circuit.

The MCR10 remote control system provides LED displays for remote channel indication, channel up and down buttons, PTT indicator, on-hook PTT capability, monitor button and indicator, intercom capability between parallel remotes and the radio, scan control button and indicator for those radios so equipped and speaker volume control.

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Figure 2. Another type of noise, *corona discharge noise*, happens when electrons flow through the antenna's tower, boom or elements and into the atmosphere when a charged cloud is near.

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Corona or brush discharge occurs when a charge builds up and electrostatic lines of force develop. More lines of force per square inch appear at the sharpest points where it is more likely a strong field will pull free electrons from the point.

Electrons pulled from a sharp point form a corona or brush discharge that causes radio noise.

This type of noise can be caused when a mobile antenna is in motion. To reduce the noise, most mobile antennas are fitted with a ball at the tip. (The ball offers protection against puncture wounds, too.) Because the mobile whip lacks a sharp point, corona discharge is reduced.

If enough electrons leave the tip, they heat and ionize air near the tip. The air

takes the form of a visible spark, known as St. Elmo's fire.

Corona is a major source of noise in the discharge category, but there are others, such as streamer currents that may precede lightning strikes and electrical arcs between objects with high voltage differences. When a charge builds up on an antenna, tower or other supporting structure, an arc may occur. The arc may leap between any insulated parts or poorly connected parts if the charge potential rises high enough—and it happens frequently.

Hardware noise

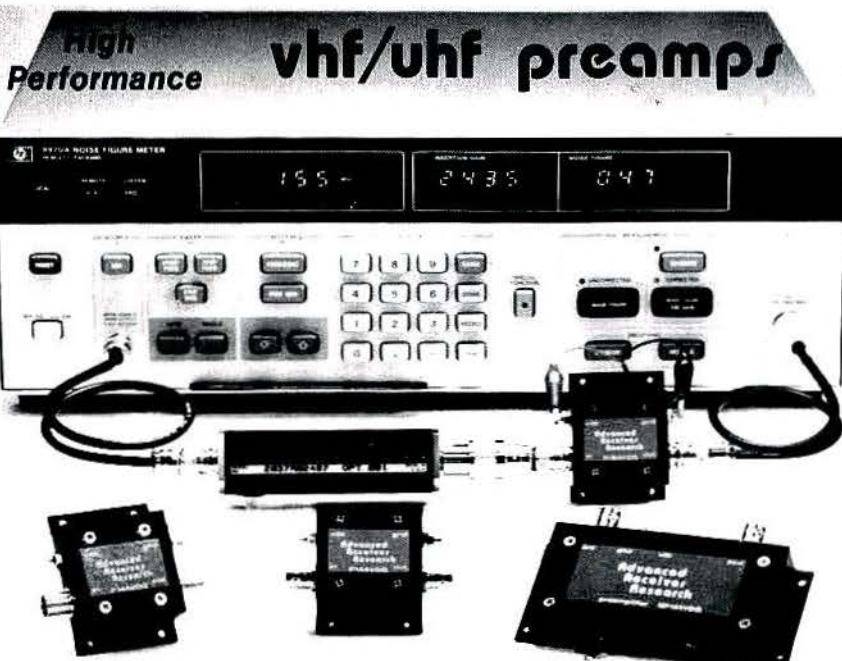
Another noise source is the antenna and tower hardware. Without proper grounding and bonding, the hardware may create multiple noise sources. Pay particular attention to any point where two conductors are in poor contact. Two conductors rubbing against each other can cause several types of noise, including rectification of strong radio signals from any nearby source.

If a feedline is not secured at short intervals, wind may cause enough movement to wear through the cable jacket, exposing the shield to intermittent contact with the tower and creating another noise source.

Joints formed of dissimilar metals, such as copper wire-to-galvanized steel tower connections for grounding, may corrode and oxidize quickly because of galvanic action. The best way to bond such joints is with exothermic welding, known by the trademark Cadweld.² Exothermic welding provides a mechanically rigid, electrically superior, low-maintenance connection that does not corrode or loosen.

Both corona and precipitation static, are well known and easy to recognize. (The abbreviation p-static often is used to refer to either or both.) P-static can raise the actual noise level 40dB to 50dB above the ambient noise level for sustained periods. The phenomenon long has been known to affect the HF radio spectrum, and it was not believed to have much effect above 50MHz. Recent, well documented reports indicate that sustained VHF and UHF p-static noise can and does occur.⁴

On HF, the elevated noise floor is readily apparent because of the nature of single-sideband (SSB) signals and the action in which rising background noise



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P150VDA, P160VDA, P170VDA	150-160, 160-170, 170-180	<1.1	15	0	DGFET	\$ 56.95
P150VDG, P160VDG, P170VDG	150-160, 160-170, 170-180	<0.5	24	+12	GaAsFET	\$ 109.95
P450VD, P460VD	450-460, 460-470	<1.8	15	-20	Bipolar	\$ 49.95
P450VDA, P460VDA	450-460, 460-470	<1.2	16	-20	Bipolar	\$ 74.95
P450VDG, P460VDG	450-460, 460-470	<0.5	16	+12	GaAsFET	\$ 109.95
P800VDG, P830VDG, P860VDG	800-830, 830-860, 860-890	<0.6	19	+12	GaAsFET	\$ 119.95

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	Freq. Ranges (MHz)	N.F. (dB)	Gain (dB)	Comp. (dBm)	Device Type	Price
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SP30VDG, SP35VDG, SP40VDG, SP45VDG	30-35, 35-40, 40-45, 45-50	<0.55	26	+12	GaAsFET	\$ 139.95
SP150VD, SP160VD, SP170VD	150-160, 160-170, 170-180	<1.6	15	0	DGFET	\$ 74.95
SP150VDA, SP160VDA, SP170VDA	150-160, 160-170, 170-180	<1.2	15	0	DGFET	\$ 86.95
SP150VDG, SP160VDG, SP170VDG	150-160, 160-170, 170-180	<0.55	24	+12	GaAsFET	\$ 139.95
SP450VD, SP460VD	450-460, 460-470	<1.9	15	-20	Bipolar	\$ 79.95
SP450VDA, SP460VDA	450-460, 460-470	<1.3	16	-20	Bipolar	\$ 104.95
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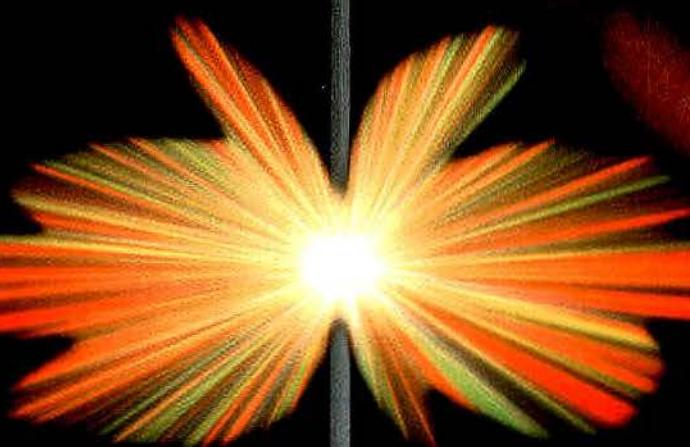
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masks weak signals. This reduces the receiver's signal-to-noise ratio, preventing otherwise usable reception.

Because FM is the most popular mode on VHF and UHF, the effects of p-static noise in those bands is not as readily apparent when it happens. Receiver desensitization as great as 20dB to 30dB may occur without unsquelching the receiver. The noise decreases system range, makes received signals noisy and causes calls to be missed. The deficiency may be attributed to "poor conditions."

Sometimes the noise rises high enough to unsquelch the receiver. When it does, a repeater may transmit white noise "for no apparent reason."

P-static's frequency spectrum may lead to the conclusion that a given receiver range is immune to the noise. But frequency discrimination applies only to linear circuitry. Large transients that drive a receiver into non-linear operation represent another desensitization mechanism.

Typical characteristics of individual

electron avalanches that make up a corona discharge include an amplitude of 10mA, a rise time of 10 nsec (nanoseconds, which are one-billionth of a second) and a decay time of 100 nsec.⁵

For a typical 50Ω antenna, this characteristic results in an impulse voltage that peaks at 0.5V. Compared to normal receiver sensitivities in the range of 0.5µV, a 0.5V signal is huge.

The electron avalanche causes the broadband noise, which in turn is modulated at the avalanche repetition rate. The repetition rate ranges from a low audio signal of a few pops per second, through the audio range and up to at least 1MHz. Through the receiver, you hear a high-pitched, screaming noise that comes in cycles two to 20 minutes long.

The pitch changes constantly. At times, it sounds like ignition or alternator noise. The noise slowly goes away as the static charge discharges through the receiver front end. Then the noise repeats as the antenna system recharges. The pattern occurs with mobile and

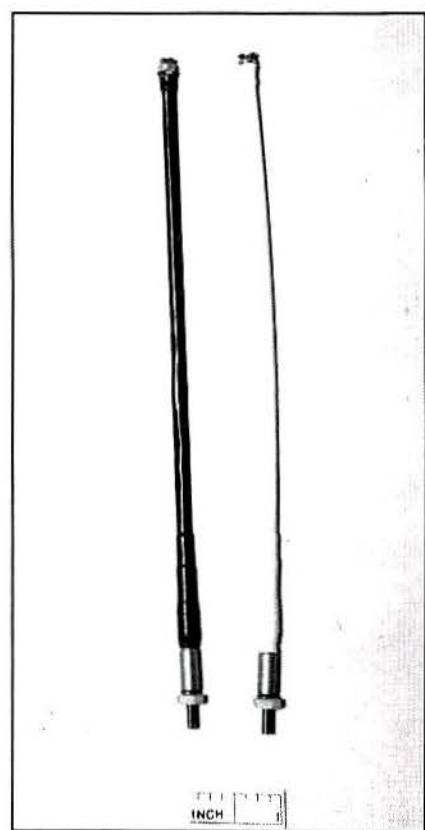


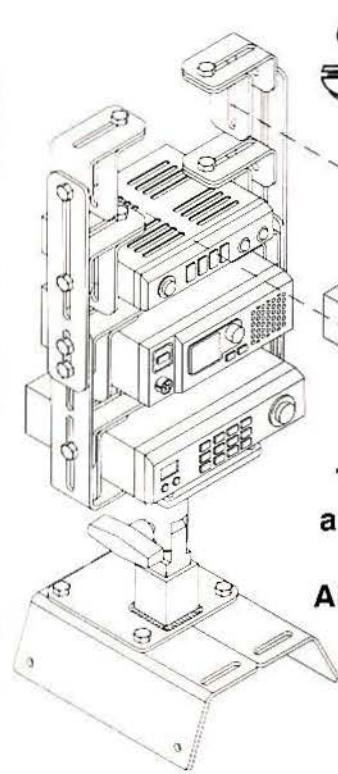
Photo 1. P-static and corona noise can be reduced or eliminated with wick dischargers. These static discharge devices bleed off the excess electrons, reducing undesired electrical noise and receiver desensitization.

fixed stations alike.

Data presented here indicate that p-static and corona noise can be reduced or eliminated with wick dischargers. (See Photo 1 above.) These static discharge devices bleed off the excess electrons, reducing undesired electrical noise and receiver desensitization. The wicks reduce a structure's discharge threshold by draining the charge before it reaches a level at which severe broadband noise is caused.

The wick is the type of device used by the aircraft industry to reduce electrostatic interference to airborne and ground station equipment. The difference is that this model has been optimized for antennas instead of airframes to ensure the antenna is not detuned, even when the wick is mounted on the antenna element.

Few aircraft manufacturers do not offer, at least as an option, a high-quality static discharger installation. These static discharge devices are just as effective



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in eliminating the same problems from antennas and towers. They deliver results on long wires, dipoles, yagis for HF through UHF, verticals, TV antennas and satellite dishes during corona and p-static charging conditions. In many cases, the discharge wicks reduce the noise level several decibels under normal weather conditions.

In the aircraft industry, the standard

procedure for discharger wick ground testing is to insulate the wick from the airframe and monitor the discharge current. The aircraft is insulated from ground and exposed to an ion flooding fixture. The current discharge levels then are used to determine how many wicks are needed and in which areas they should be placed. Aircraft are subject to the influence of more variables

than antennas and towers are.

To test the dischargers, two identical 7-element 50MHz yagis were assembled and mounted 30 feet high (1.5 wavelength). One wavelength separated the yagis. Both were fed with equal-length feedlines. (See Figure 3 below). Both yagis were swept with a spectrum analyzer-tracking generator combination to verify their resonance at the same frequency.



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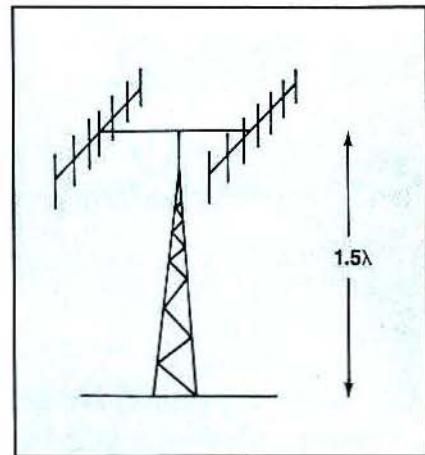


Figure 3. To test the dischargers, two identical 7-element 50MHz yagis were assembled and mounted 30 feet high (1.5 wavelength).

The antennas were lowered, and a static discharger was attached to each end of the boom on one yagi. (See Figure 4 below.) The yagis were raised back to 30 feet. The yagi without the discharger was used as a control antenna.

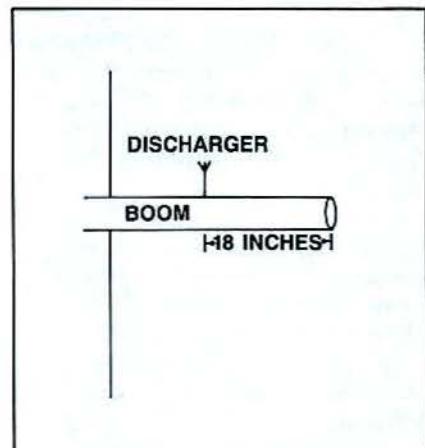


Figure 4. A static discharger was attached to each end of the boom on one yagi. The yagi without the discharger was used as a control antenna.



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The results are shown in Figure 6 on page 36. The reduction in corona discharge and p-static attributed to the dischargers is not trivial.

The noise measurements were made as an approaching weather front caused a few sprinkles of rain to fall as the noise level peaked. It does not have to be raining for corona and p-static discharge to take place. A weather front with embed-

ded charged clouds moving in the antenna's vicinity causes electrons to build up.

When the discharge threshold is reached and discharging begins, the noise starts. The object of using the wicks is to reduce the discharge threshold. With a lower threshold, electrons drain at a lower potential that does not cause noise or that causes less noise. If

the charging intensity is high enough, some noise will be heard. But the noise level is likely to be 20dB to 30dB less than it would be without the wicks.

Efforts were made to find the wicks' optimum mounting location. The first noise graph (Figure 6) was made with the dischargers mounted vertically, 18 inches from the ends of the 40-foot boom. Noise reduction was significant.

Next, the wicks were positioned on the ends of the boom and in the plane of the boom. (See Figure 5 below). Fig-

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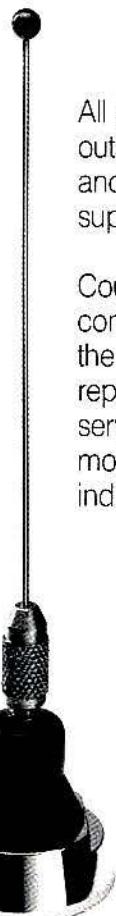
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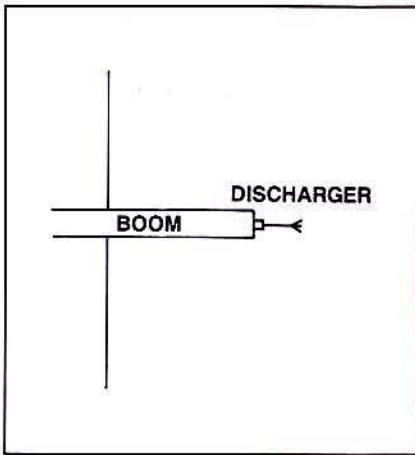


Figure 5. A second test was made with the wicks positioned on the ends of the boom and in the plane of the boom.

ure 7 on page 38 shows noise results of the Figure 5 wick position. The performance improvement probably results from the discharger being in a more prominent dc field area of the antenna.

Dischargers can be mounted vertically at the end of the boom if they are within three inches of the end.

Data are being collected with the dischargers mounted on the driven element of a seven-element yagi to compare the effectiveness of boom, driven element and parasitic element mounting positions.

Various methods were used to record the antenna and discharger performance. Noise graphs were prepared from data collected by an eight-channel analog-to-digital converter connected to an IBM PC-AT-compatible computer.

A three-range ammeter was built to measure individual discharger currents during various weather conditions. The ammeter read in 100-picoamp, 100-nanoamp and 100-microamp scales.

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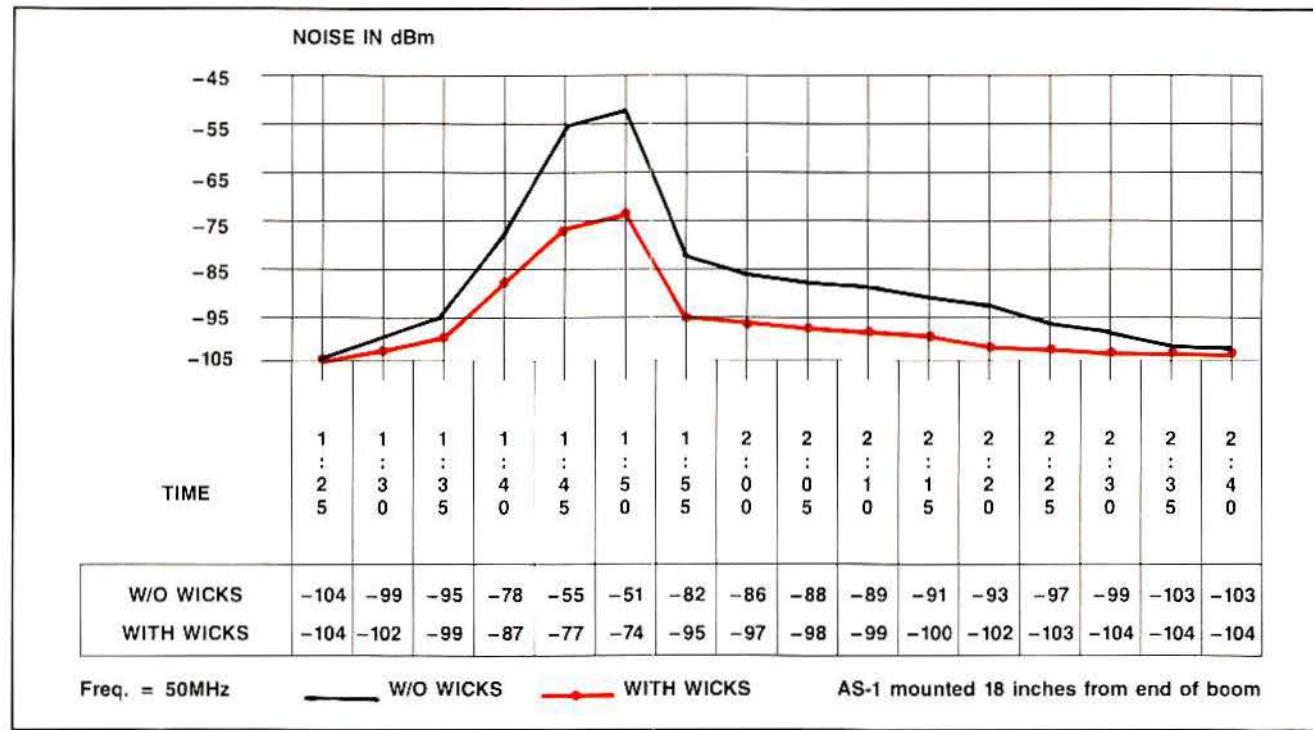
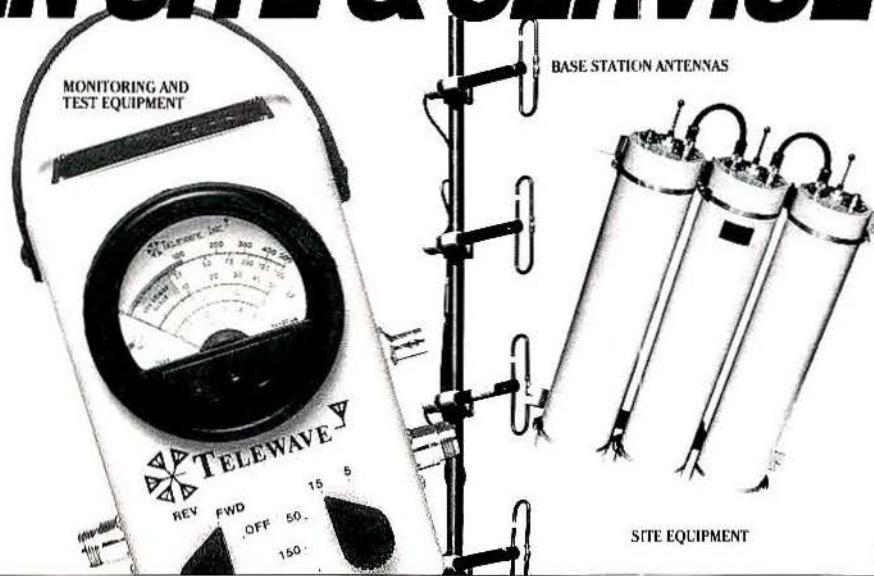


Figure 6. Noise measurements were made on the yagi test setup shown in Figure 3 as an approaching weather front caused a few sprinkles of rain to fall and the noise level peaked. It does not have to be raining for corona and p-static discharge to take place. The graph compares noise received on the yagi with dischargers with noise received on the yagi without dischargers.

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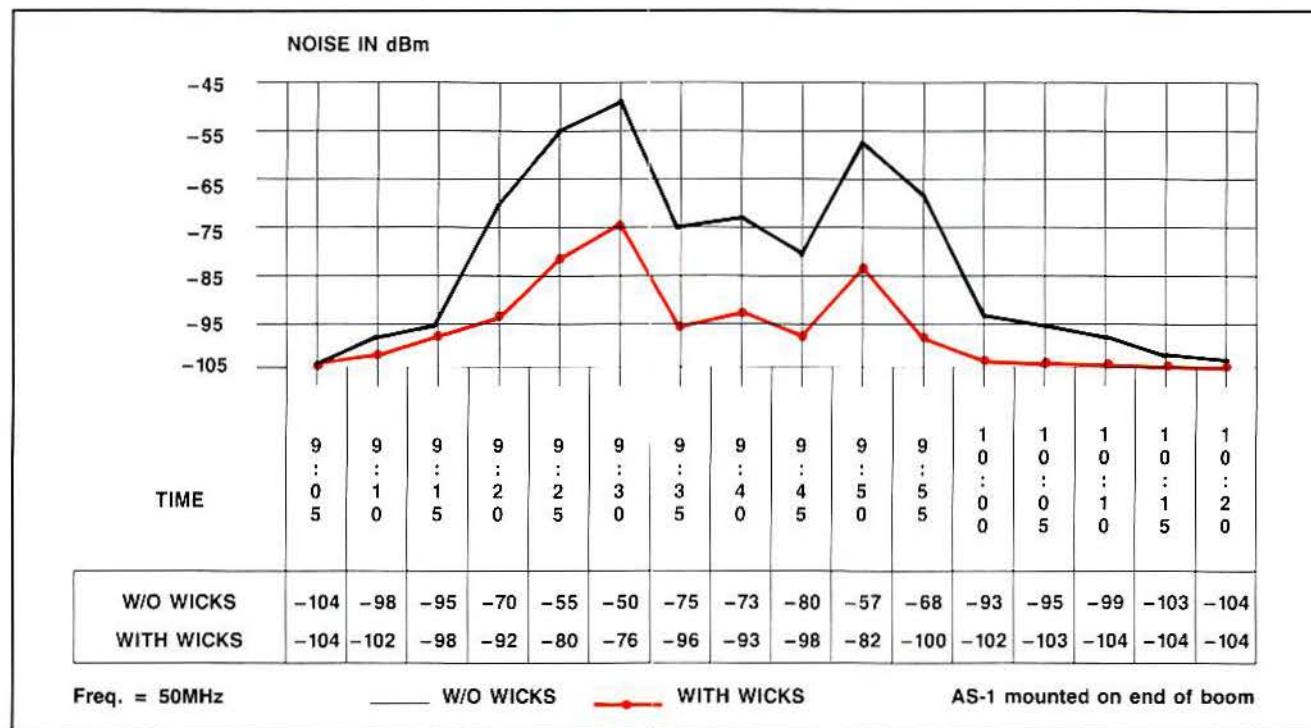


Figure 7. A second set of noise measurements made with the wicks positioned at the ends of the boom shows improved performance that probably results from the discharger being in a more prominent dc field area of the antenna.

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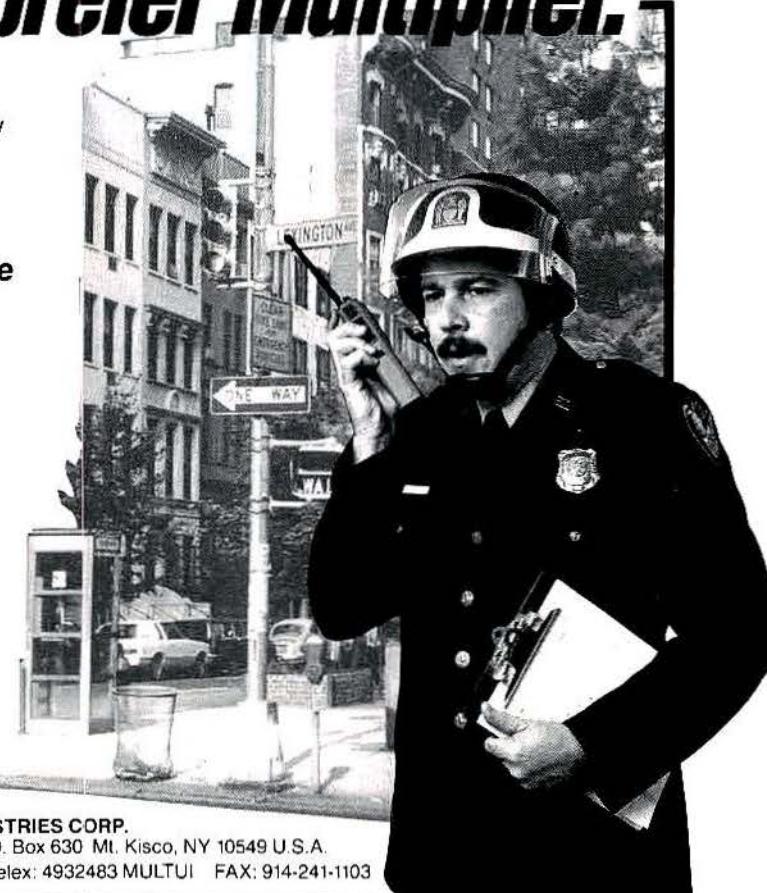
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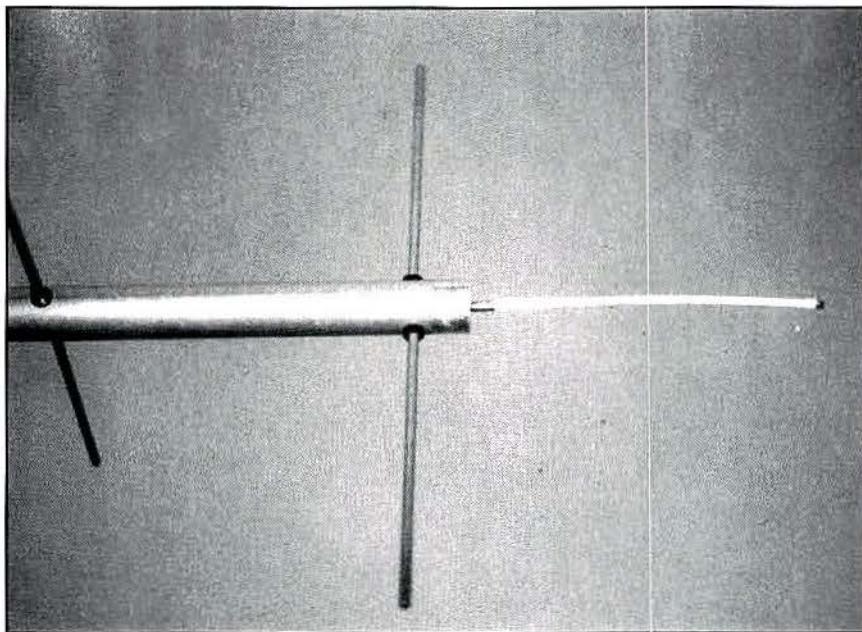


Photo 2. A discharger mounted on the boom of a 430MHz, circularly polarized satellite antenna.

for fair-weather discharger current, changes in readings can detect an approaching front when it is still 20 miles

to 30 miles away. Using the ammeter in this way requires a resolution of at least 1.0 picoamp.

The onset of audible noise did not happen simultaneous with discharger increases above the normal baseline. Usually, the baseline current had to be exceeded by at least 10 times before detectable audio noise resulted. Nevertheless, the receiver front end can be desensitized by 10dB to 20dB before noise is heard.

Mounting

The dischargers are 0.187-inch (3/16") x 6.75-inches long. Each discharger requires one tapped 4-40 mounting hole. Only the 0.25-inch base of the discharger is metal, so antennas are not significantly detuned even when a discharger is mounted on an active element at frequencies below 470MHz.

Most antennas are at dc ground potential. With such antennas, no modification is required when a discharger is mounted. A discharger mounted on an element that is not dc grounded should be bypassed to ground with a 100KΩ or 1MΩ resistor to provide the dc path.

Photo 2 above shows a discharger

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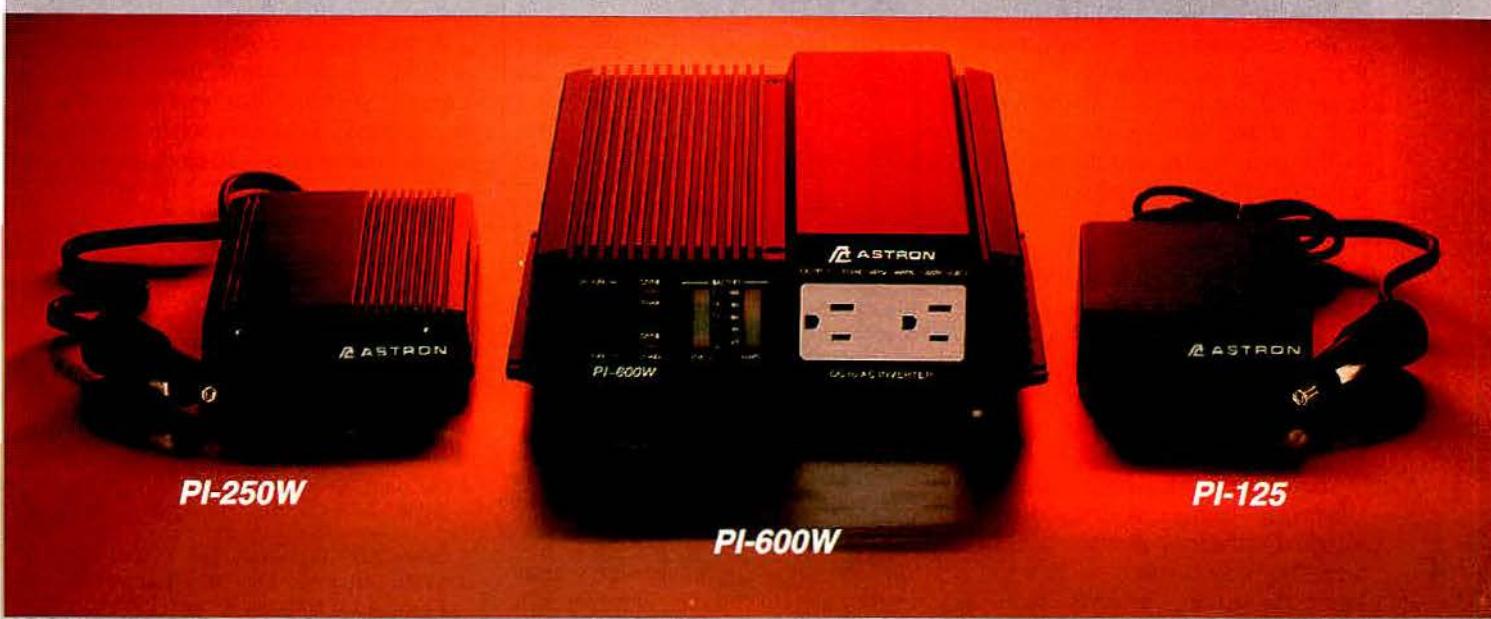


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Surge:	200 watts	500 watts	1500 watts
Continuous:	100 watts	200 watts	500 watts
Input Voltage:	10 to 15 VDC	10 15 VDC	10 to 15 VDC
Output voltage:	115 VAC RMS \pm 5%	115 VAC RMS \pm 5%	115 VAC RMS \pm 5%
Output frequency:	60 Hz \pm 2%	60 Hz \pm 0.01%	60 Hz \pm 0.01%
Output waveform:	modified sinewave, phase corrected	modified sinewave, phase corrected	modified sinewave, phase corrected
Efficiency:	90%	90%	90%
Low battery alarm:	10.7 V	10.7 V	10.7 V
Low battery shutdown:	10 V	10 V	10 V
Dimensions (H x W x L):	1.2" x 3.5" x 4.5"	1.5" x 4.5" x 6"	3" x 9" x 10"
Weight:	14 oz.	1.25 lbs.	5.25 lbs.
Protection features:			
Over temperature:	Electronic shutdown	Electronic shutdown	Electronic shutdown
Overload:	Electronic shutdown	Electronic shutdown	Electronic shutdown
Short Circuit:	Electronic shutdown	Electronic shutdown	Electronic shutdown
Reverse polarity	Fuse	Fuse	Fuse

Circle (36) on Fast Fact Card

mounted on the boom of a 430MHz, circularly polarized satellite antenna.

You can demonstrate how effective the discharger is by insulating it from the boom and connecting a single wire to a zero-center, 150 μ A meter to ground, as shown in Figure 8 to the right. The meter should be protected with back-to-back diodes.

As much as 100 μ A of discharger current will flow when the noise level rises to 40dB above the ambient level. The readings may differ at various installations, but the correlation will be evident.

A zero-centered meter is used because the discharge can be positive-point corona or negative-point corona.

These dischargers are not lightning "deterrent" devices. Although they are installed in the most prominent dc field area, they may become "sacrificial" if lightning strikes, possibly reducing damage to more expensive equipment.

Once installed, dischargers require no maintenance. They rarely need to be replaced.

As a precaution, check them to be

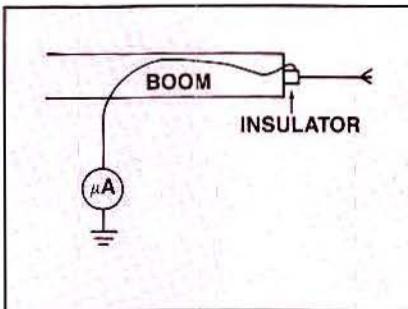


Figure 8. To demonstrate how effective the discharger is, insulate it from the boom and connect a single wire to a zero-center, 150 μ A meter to ground. Protect the meter with back-to-back diodes. As much as 100 μ A of discharger current will flow when the noise level rises to 40dB above the ambient level. The readings may differ at various installations, but the correlation will be evident.

sure they show continuity with whatever they are attached to. There must be an electrical path from the discharger to the structure. Other than checking for physical damage and a satisfactory mechanical connection while you perform other antenna and feedline inspections,

you will find the dischargers are maintenance-free.

A discharger's resistance is in excess of 20M Ω , so to measure its resistance, a driving potential of at least 100V may be required. Take care when making measurements at a voltage that high.

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How to configure linked radio networks

Wide-area radio communications system coverage can be achieved with multiple sites linked into a network. Here are some considerations for choosing between half-duplex and full-duplex configurations.

By A.O.J. Woodfield

Linked radio networks provide wide-area coverage by connecting individual radio repeaters or base stations with radio links, microwave links or traditional cable pairs.

Many linking methods are available. Some are relatively complex, such as voting system combining.

Simpler linking methods are available, such as half-duplex and full-duplex linking. Properly configured, these networks support continuous-tone controlled squelch system (CTCSS) signaling.

Figure 1 below shows a conventional wide-area linked system with four sites linked via UHF radio. A repeater or

Woodfield is manager of Uni-Lab New Zealand, Christchurch, New Zealand.

base station at each site provides local-area mobile coverage.

Linking methods

► Half-duplex linking provides a connection that is used in only one direction at a time. An in-vehicle cross-band link that uses a pair of mobile units connected back-to-back is a common example.

► Full-duplex linking provides a two-way link in which speech or data traffic or both can flow in both directions simultaneously. Telephones and cellular radios are examples of full-duplex links.

Incidentally, the term "full-duplex base station" refers to a receiver and a transmitter operating at a remote site, perhaps in full duplex, where the received audio is not retransmitted over the transmitter at the same site. A taxi

dispatch system in which car-to-car transmissions are not desired, only a link between each mobile and the dispatcher or control center is an example.

In standard mobile radio networks it often is quite satisfactory to use the more limited half-duplex linking techniques. Half-duplex linking normally costs less because less equipment is required. Nevertheless, full-duplex linking provides some advantages and may be essential for some system applications.

Figures referred to in the following text show the wiring required at each site. Some details are omitted to keep the diagrams as clear as possible, and some assumptions are made about input and output signals, including:

- Active LOW PTT (push-to-talk) and Rx Gate (carrier-operated relay [COR] signal or Receiver Gate signal) signals are assumed in all of the diagrams. In other words, a ground on the PTT input turns on the transmitter, and when the receiver receives a valid signal, the COR or Rx Gate signal line goes to ground.

Some alternate systems may use -48Vdc signals, active HIGH PTT lines or even loop-keying or tail-keying signals. They all are similar to the system shown here, but they require slightly different circuit arrangements to provide the same functions illustrated.

- Duplexers and antennas are not shown.

- Power supply details are not described.

Half-duplex linking

The major advantage of half-duplex linking is simplicity. With simplicity comes reduced cost, not only from a

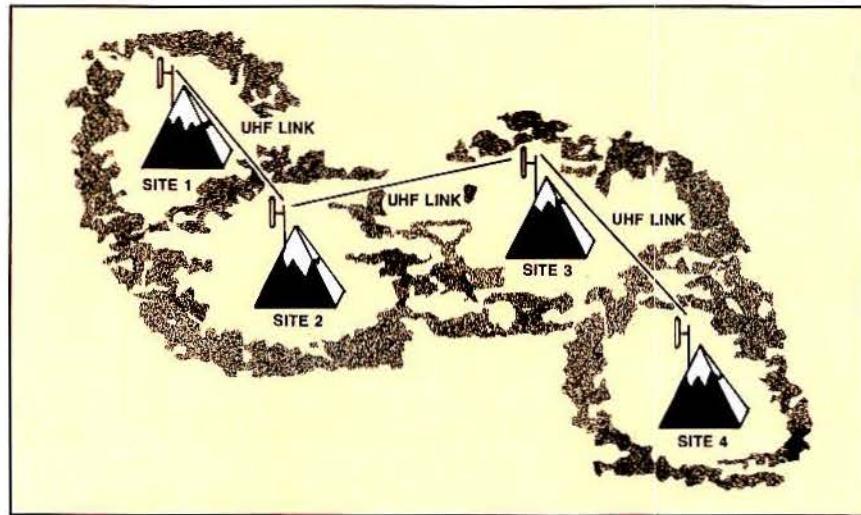


Figure 1. This conventional wide-area linked system has four sites linked via UHF radio. A repeater or base station at each site provides local-area mobile coverage.

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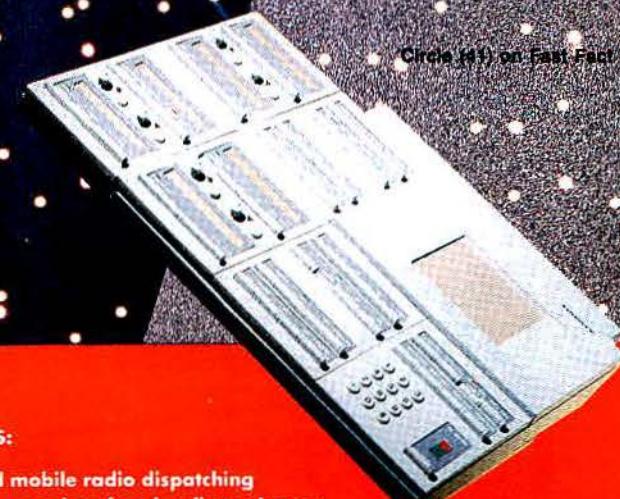
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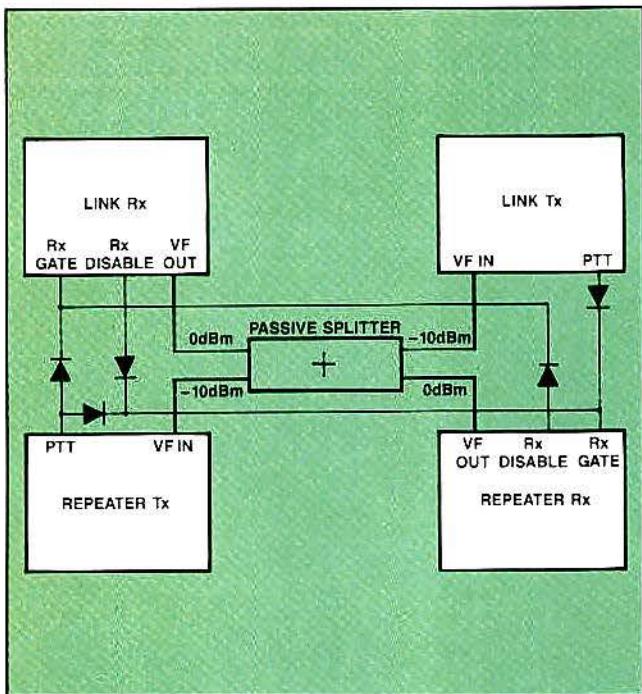


Figure 2. This is the wiring diagram for an end terminal site, such as Site 1 or Site 4 in Figure 1. In this case, the system uses repeaters at each site to repeat the received signal at the same site for other mobiles in the area to hear.

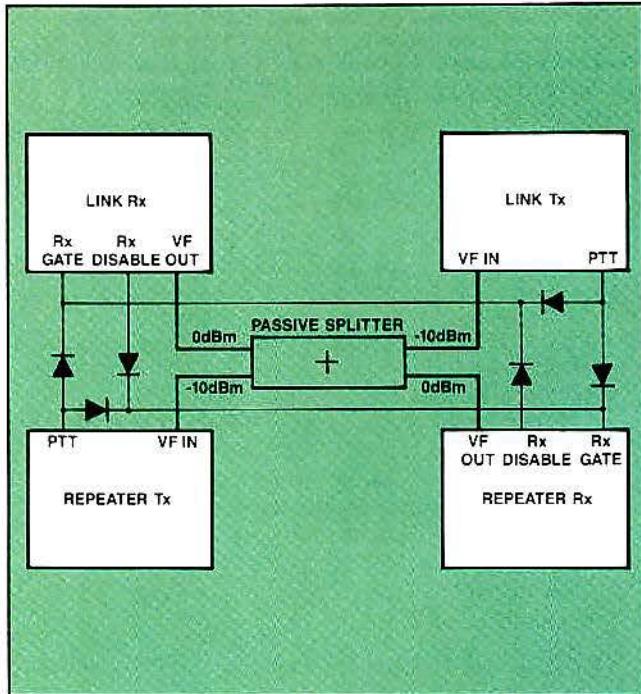


Figure 3. Midway sites differ slightly from terminal sites in half-duplex linked systems—one diode is added. To let either end of the system to receive signals from the opposite end, intermediate sites must have full-duplex links.

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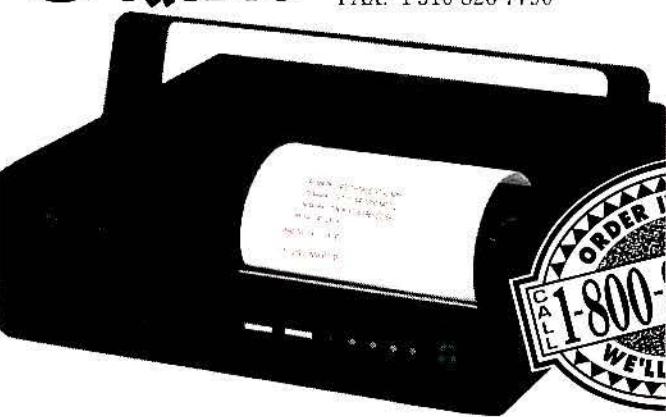
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reduction in system equipment such as audio splitters, combiners and antenna duplexers, but also from reduced maintenance costs.

In the half-duplex system, the link connects audio from one base station to another, or from one repeater to another, in only one direction at one time, retransmitting the audio as required at each of the sites in turn.

Figure 2 above shows an example of the wiring for an end terminal site, such as Site 1 or Site 4 in Figure 1. In this case, the system uses repeaters at each site to repeat the received signal at the same site for other mobiles in the area to hear.

In addition, the system links the received signal from the terminal site to other sites in the system. Diodes provide the connection paths between the Rx Gate output signals and the PTT inputs of the local repeater transmitter and the link transmitter.

The two extra diodes connecting with the Rx Disable inputs on the receivers ensure signal collisions do not occur. For example, if the link receiver is busy and its audio is being retransmitted by the local repeater transmitter, then if a local mobile tries to call (perhaps because the mobile operator has his vol-



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ume control turned down), the diode going to the repeater Rx Disable input prevents the repeater receiver gate from keying the system.

Similarly, if the local repeater is being used and a call is made from another site, a possibility in such systems because of keying delays, then the link receiver is prevented from opening by this Rx Disable logic.

The passive splitter in Figure 2 frequently is a simple resistor splitter-combiner that allows the audio to be split around the site equipment.

The four-port unit shown illustrates the signal level losses of a four-port, 600Ω , fully balanced unit that I often use. The unit typically has port-to-port loss of about 10dB. This unit may sound complex, but it consists of a small

25mm x 25mm printed circuit board with eight resistors.

The midway sites differ only slightly from terminal sites in half-duplex linked systems. Figure 3 on page 46 shows the difference—one extra diode added. To allow for either end of the system to receive signals from the opposite end, these intermediate sites must have their links operating in full duplex. These sites may receive a signal from a downstream site, for example, and must retransmit it locally on the repeater transmitter.

Then, as distinct from an end site, it also must retransmit the same signal upstream to the next site, where the signal is transmitted again on the repeater, for the benefit of local mobiles in the coverage area.

The extra diode keys the link transmitter, a function not required on an end terminal site. Note that the link receiver does not operate continuously, nor can the repeater receiver locally receive

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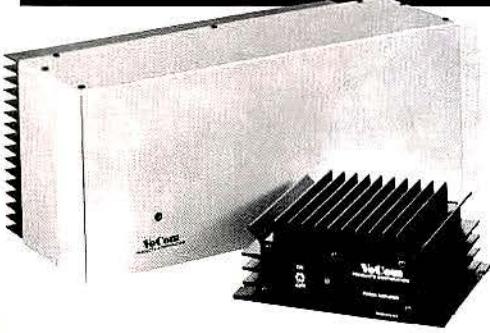
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The major limitation of half-duplex linking involves link timing.

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any signals from local mobiles while the link receiver is receiving signals from the remote site because these signals are retransmitted locally by the repeater transmitter.

The Rx Disable diodes on the repeater receiver would not be necessary where mobile transmitters are prevented from being keyed while a signal is being received at the mobile. But with this diode in place, even when such protected mobiles are used, it provides low-cost assurance against the possibility of a high-power mobile attempting to access the system from a weak-signal area.

Half-duplex limitations

The major limitation of half-duplex linking involves link timing. If a signal arrives at a repeater receiver, then typically it may take around 300mS for that

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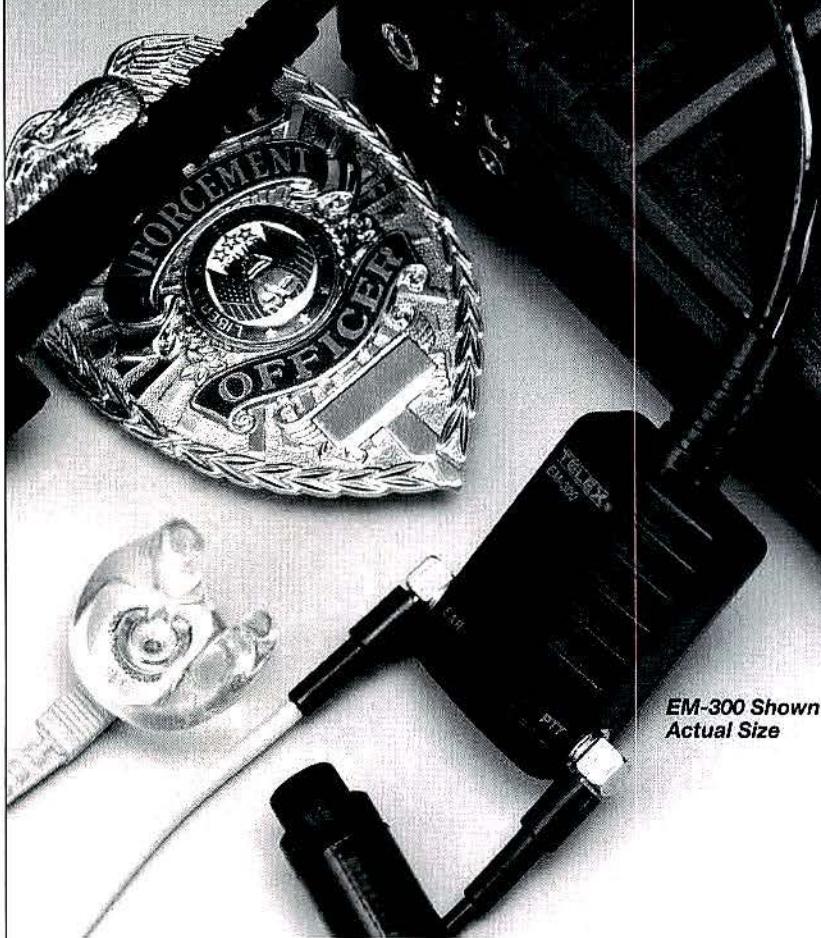


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signal to appear at the far end of a four-site network as shown in Figure 1.

This time consists of a 50mS delay at the repeater receiver for it to gate; another 30mS for each link transmitter to turn on; 50mS for each link receiver to gate, and finally 30mS for the remote repeater transmitter to turn on.

These figures are fairly typical of most manufacturers' transmitters and receivers, and they assume good signal levels throughout the network. If weak signals arrive, then receivers may take significantly longer to open.

If the system uses CTCSS, then delays really start to accumulate. With mid-range CTCSS tones, decode delays are about 90mS, giving around 400mS link delays from end to end. And if

If weak signals arrive, then receivers may take significantly longer to open.

CTCSS is used on the link equipment too, then the total delay may be as long as 600mS.

With radio systems that carry only voice traffic, these delays usually are acceptable. Using CTCSS can be an advantage in linked networks of this type, in which users might use one CTCSS tone to access the local repeater only, and a second CTCSS tone for link access. This adds considerably to system flexibility.

If the linked system is used for data, as well as voice, then these delays result in some lengthy data transfers, particularly when packet protocols that require frequent hand-shaking among users are involved. An example of how much slower data transmission can be in a CTCSS-linked network illustrates the point.

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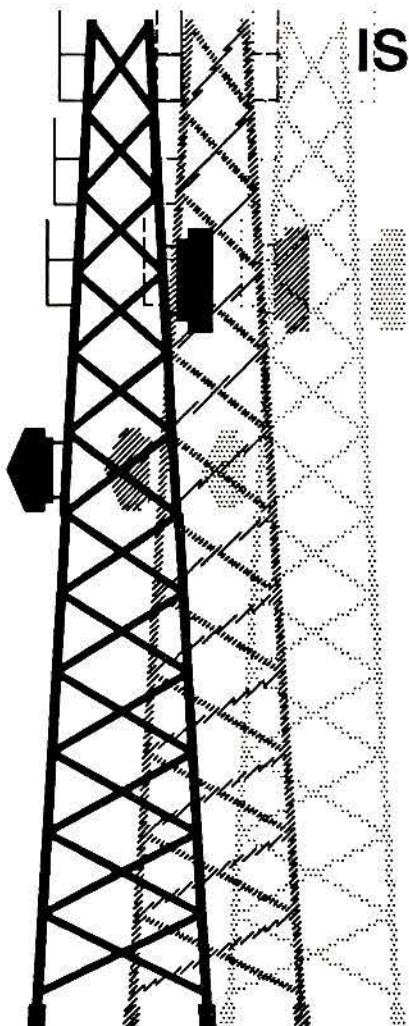
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message might be the transmission of name and address information.

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Assuming no transmission delays, the message takes 275mS to send (660 bits \div 2,400bps).

But adding the 300mS link delay for the system shown in Figure 1 with CTCSS extends the transmission time to 575mS, almost twice as long. If longer data messages are sent, the overall effective data rate rises, but not in the case of packet radio protocols because messages are broken into shorter packets by the modems.

Full-duplex linking provides a bi-directional path for signals through the mobile radio network.

This illustrates the advantages of a full-duplex linked network because the extra delays occurring in the half-duplex system are avoided. Unfortunately, full-duplex linked systems are more expensive and complex, so inevitably there is a tradeoff between design and operational requirements.

Full-duplex linking

Full-duplex linking provides a bi-directional path for signals through the mobile radio network. Full-duplex systems frequently are used, as in telephone networks. The difference in most mobile radio applications is that the mobiles in radio networks normally operate half-duplex.

A typical system layout in Figure 4 on page 54 shows only one midway site with a repeater, rather than the two midway sites that might be shown in an attempt to illustrate an equivalent of the Figure 1 network. A second midway site

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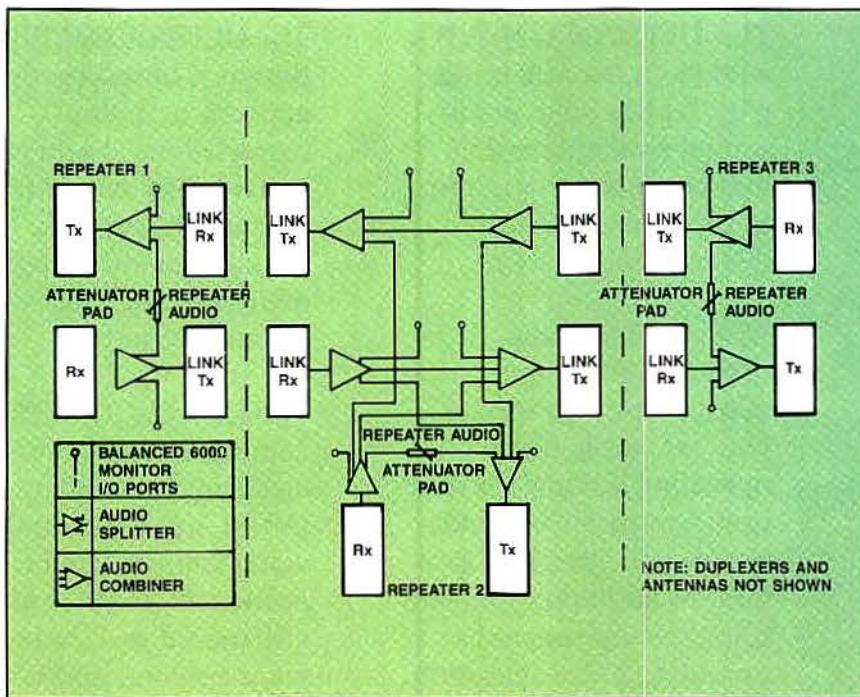


Figure 4. A three-site system uses one midway repeater site configuration. Additional midway sites, as in the four-site system shown in Figure 1, would be configured identically.

would be identical to the midway site shown in Figure 4.

An important feature of this configuration is the use of active splitters and combiners, which are necessary to provide both audio path isolation and correct levels throughout the network. The two audio paths within the linking equipment never are joined together. They meet only at repeater sites where the local repeater receiver signal is folded back to the local transmitter through the attenuator pads shown in Figure 4.

Audio normally is not folded back anywhere else to avoid problems such as oscillation, feedback and audible ringing in the system.

Preventing these problems is essential. Because this isolation is required, it is not possible to use the simple resistive pads that are used in the half-duplex system previously described.

Figure 5 on page 56 shows a typical active splitter-combiner. These can be quite complex units, especially for sites such as Figure 4's midway site where fully balanced 600Ω inter-unit audio is used.

Even so, this equipment still can be quite compact. In the case of Figure 4's midway site, two modules the height of

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...the local repeater receiver signal is folded back to the local transmitter through the attenuator pads...

one rack unit provide all the required equipment for the four-wire balanced audio signaling and allow all the levels to be set correctly.

Figure 6 on page 57 shows a typical audio path around the system, where the audio is being received from the repeater receiver on the midway site. The audio initially is fed back via the splitter through an attenuator into the local repeater transmitter so other mobiles in the local area can monitor the call.

Two additional ports on this splitter pass audio to the linking equipment,

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MOTOROLA

both downstream and upstream to the other sites, where the appropriate area repeater transmitters repeat the mobile's call. The signal stops at these end sites and is not folded back down the link again.

One other item is shown in Figure 6 and in Figure 4, as well. There are additional ports on the splitter and combiners that serve either as test points (for level measurements, for example) or for attachment to other equipment, such as local site telemetry or status monitoring equipment.

Timing with speech and data signals over this full-duplex link is less of a problem, assuming the link operates permanently. In this case, because the links are established, the only delays in the network are from the repeater equipment.

For the example previously described, the end-to-end delay is reduced from 300mS to 80mS, which is barely noticeable. Even with CTCSS in the system, the link delay extends only to about

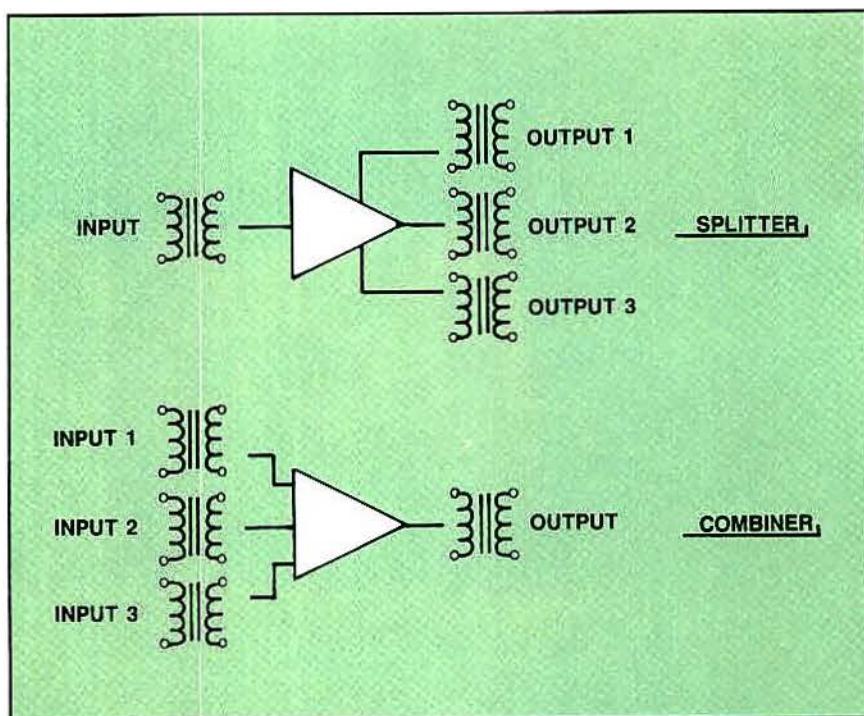


Figure 5. An active splitter-combiner can be quite complex, especially for sites such as Figure 4's midway site where fully balanced 600Ω inter-unit audio is used.

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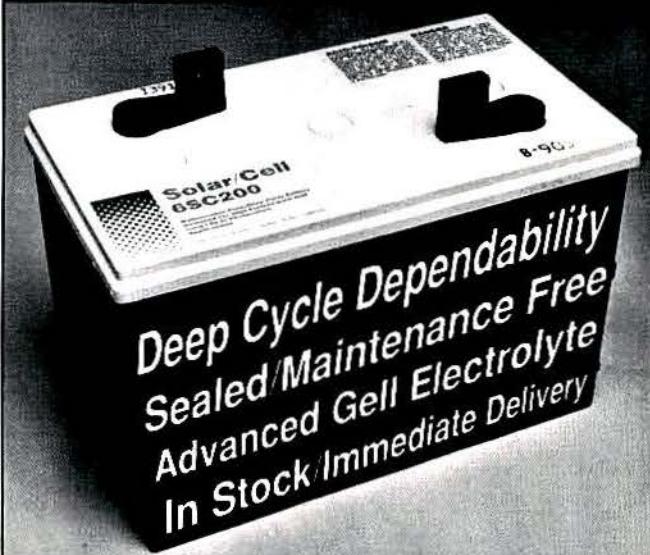
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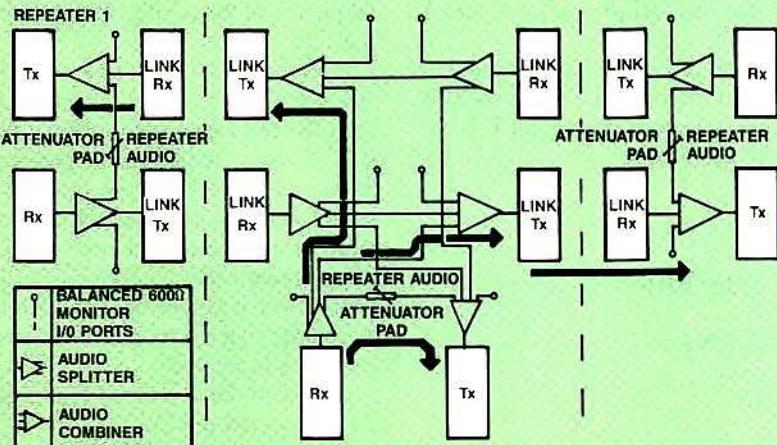


Figure 6. A typical audio path around the system initially feeds audio received from the repeater receiver on the midway site back via the splitter through an attenuator into the local repeater transmitter so other mobiles in the local area can monitor the call.

170mS, about half the delay of the simple half-duplex system.

These timing advantages become even greater in view of more realistic applications, such as systems for larger statewide or nationwide radio networks, in which five or more links may be used.

When it comes time to purchase or to design a new linked mobile radio system, these descriptions of half-duplex and full-duplex linking methods may provide a useful starting point for decision-making.

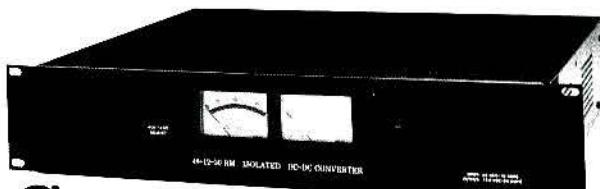
Points that normally are taken into consideration include speech and data applications and the use of CTCSS. Linking delays have a bearing on the use of half-duplex vs. full-duplex networks for specific applications.

Additional reading

Woodfield, A.O.J., "Using SINAD Voting Combiners in Mobile Radio Networks," *Mobile Radio Technology*, April 1993.



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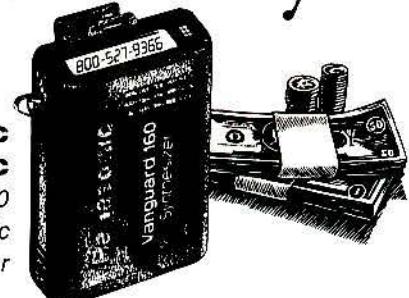
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Technically speaking

(continued from page 8)

10dB, then the return loss at the antenna is:

$$\begin{aligned} R_L &= 2(L_L) \\ &= 10 - 2(2) \\ &= 6 \text{dB} \end{aligned}$$

where

R_L = return loss in decibels at the transmitter

L_L = transmission line loss

It is necessary to multiply the line loss by a factor of 2 because both the forward power and the reflected power are attenuated by the line loss. In this example, the forward power is 2dB lower at the antenna, and the reflected power is 2dB higher at the antenna.

► **Reflection coefficient**—Simply stated, reflection coefficient is the ratio of

voltage of the *incident* wave to voltage of the *reflected* wave.

Because voltage is proportional to the square root of the power, reflection can be defined as $\sqrt{(P_R)}/\sqrt{(P_F)}$ or simply $\sqrt{(P_R/P_F)}$.

For example, if the forward power is 100W and the reflected power is 25W, then the reflection coefficient Γ is calculated as follows:

$$\begin{aligned} \Gamma &= \sqrt{(25/100)} \\ &= \sqrt{(0.25)} \\ &= 0.5 \end{aligned}$$

► **Reflected-to-forward power ratio**—The reflected-to-forward power ratio unit of measure probably is the most familiar to land mobile radio technicians because they favor the use of an in-line directional wattmeter to measure forward and reflected power on the trans-

mission line.

It is simple, then, just to compare the reflected power reading with the forward power reading to get a quick mental picture of the degree of mismatch on the line.

For example, if the forward power is 100W and the reflected power is 25W, then the ratio (reflected-to-forward) is 0.25. Notice that this figure is the *square of the reflection coefficient* that was obtained using the same reflected and forward power measurements.

► **Percent reflected power**—The percent reflected power figure is obtained by multiplying the reflected-to-forward power ratio by 100.

For example, a ratio of 0.25 equals 25% reflected power.

► **Transmission loss**—Transmission loss is the actual loss in the transmitted signal resulting from the mismatch.

For example, with 100W of forward power at the antenna and 25W of reflected power, only 75% of the *available power* is transmitted. The transmission loss is:

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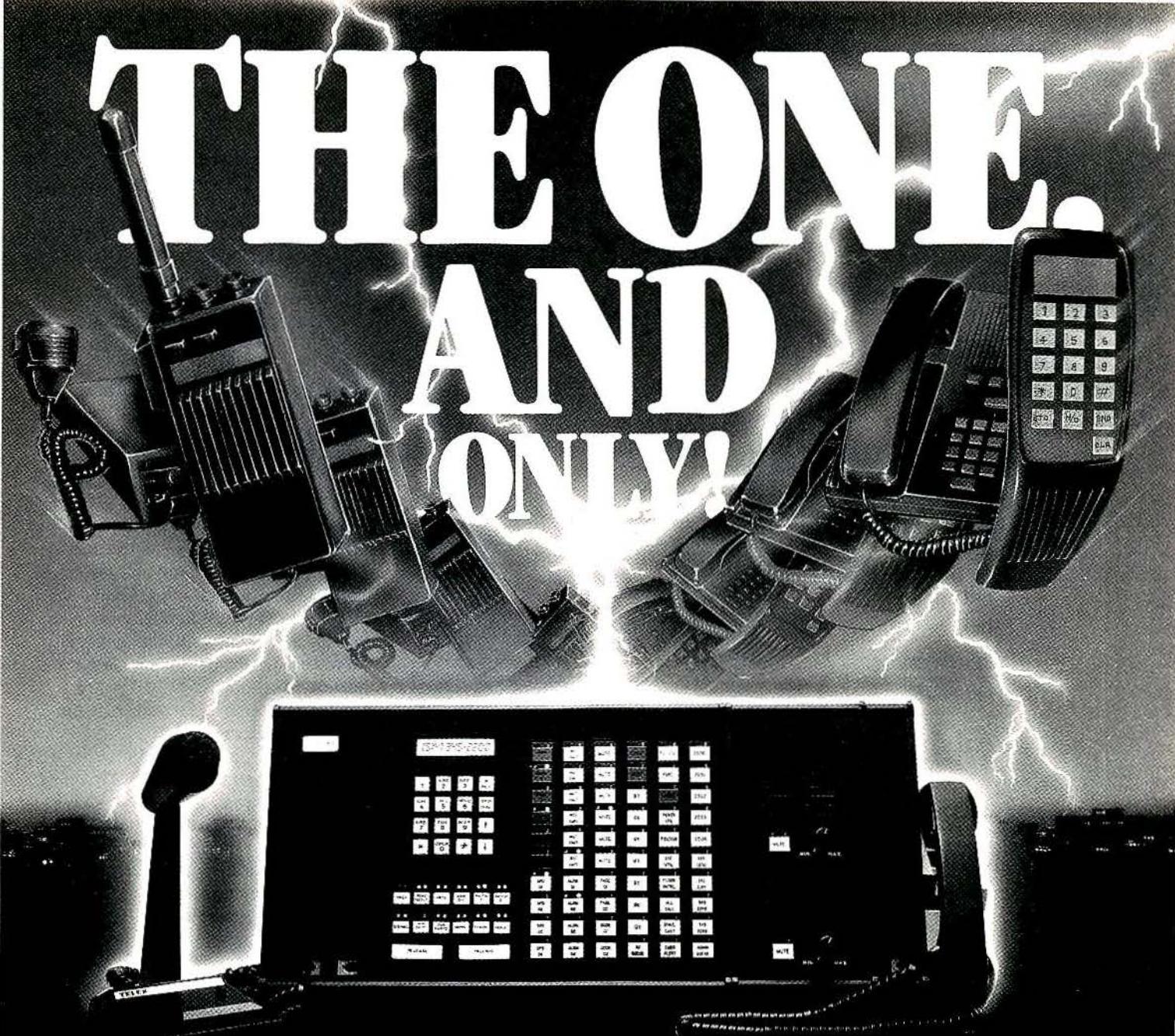
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Technically speaking

$$\begin{aligned}
 T_L &= 10 \log(1 - r) \\
 &= 10 \log(1 - 0.25) \\
 &= 10 \log(0.75) \\
 &= 10 \times -0.125 \\
 &= -1.25 \text{ dB}
 \end{aligned}$$

Conversion formulae: The following formulae can be used to convert between any of the measuring units discussed.

$$\begin{aligned}
 S &= \frac{1+\sqrt{r}}{1-\sqrt{r}} \\
 S &= \frac{1+\Gamma}{1-\Gamma} \\
 S &= \frac{1+10^{-(R_L/20)}}{1-10^{-(R_L/20)}} \\
 r &= \left(\frac{S-1}{S+1} \right)^2
 \end{aligned}$$

$$\begin{aligned}
 r &= \Gamma^2 \\
 r &= 10^{-(R_L/20)} \\
 \Gamma &= \sqrt{r} \\
 \Gamma &= \frac{S-1}{S+1} \\
 \Gamma &= 10^{-(R_L/20)}
 \end{aligned}$$

$$R_L = 10 \log \left[\left(\frac{1}{S+1} \right)^2 \right]$$

$$R_L = 10 \log \left(\frac{1}{r} \right)$$

$$R_L = 10 \log \left(\frac{1}{\Gamma^2} \right)$$

$$T_L = 10 \log \left[1 - \left(\frac{S-1}{S+1} \right)^2 \right]$$

$$T_L = 10 \log(1 - \Gamma^2)$$

$$T_L = 10 \log(1 - r)$$

$$R = 100r$$

where

$$S = \text{VSWR}$$

$$\Gamma = \text{reflection coefficient}$$

$$T_L = \text{transmission loss in decibels}$$

$$R_L = \text{return loss in decibels}$$

$$r = \text{reflected-to-forward power ratio}$$

$$R = \text{percent reflected power}$$

Nomograph—The nomograph in Figure 1 on page 8 converts between equivalent units of VSWR, return loss, percent reflected power, reflection coefficient and transmission loss that lie on the same line. At a glance, you can convert from any unit of measure to another.

There are a few advantages that are not so apparent at first glance.

For example, if you know the VSWR at the transmitter and the line loss, you can find the VSWR at the antenna by

using the following example as a guide.

The VSWR at the transmitter is 2.0:1, and the line loss is 2.5dB. Locate 2.0 on the VSWR scale and read the equivalent return loss in decibels on the next scale. It is approximately 9.5dB.

Subtract twice the line loss (2 \times 2.5 = 5) from the return loss reading, and move to that point on the return loss scale. This point will be 4.5dB on the return loss scale, which is equivalent to a VSWR of approximately 4:1 at the antenna.

The nomograph can be used to determine the maximum VSWR that can be seen at the transmitter for a given amount of line loss.

For example, suppose the line loss is 3.0dB. Double this figure and move to 6 on the return loss scale. Follow the line out to the VSWR scale, and note that for a 3dB line loss, the maximum VSWR seen at the transmitter is approximately 3.0:1.

The *transmission loss* scale may provide some surprises.

For example, notice that for a VSWR of 3.0:1, the transmission loss is only 1.25dB. It appears, then, that a VSWR of 3.0:1 is not so terrible after all.

Here is the catch: Modern radio transmitters have an automatic power reduction circuit that limits output when a high VSWR is detected. Thus, the practical transmission loss would be much greater for such radios than would be indicated by the nomograph.

For example, if power output is reduced 50% for a VSWR of 3.0:1, this reduction would add 3dB to the *normal* transmission loss to make the practical effect a net 4.25dB transmission loss.

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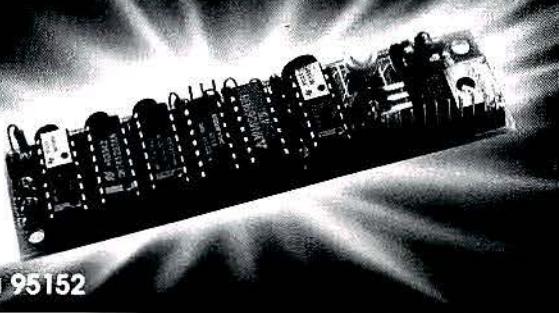
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Publicity campaign, views of future highlight Mobile Communications Marketplace

San Francisco was the site for the Mobile Communications Marketplace trade show Sept. 21-25. The show is sponsored by Telocator, a Washington, DC-based trade association whose constituents include radiopaging system operators and members who want to offer future personal communications services (PCS).

The audience for the opening session saw excerpts of TV interviews and newspaper coverage generated by the association's yearlong campaign to highlight positive aspects of pager use. The coverage helped to offset adverse publicity the paging industry received in 1991 in stories about illegal drug traffickers' use of pagers.

In a campaign underwritten by Motorola, Schaumburg, IL, Telocator made a spokesperson available for TV interviews and sent information packages to newspapers. The spokesperson, Michael Fortino of San Francisco-based Fortino & Associates, a management training and consulting firm, appeared on many TV stations' news and talk programs. Newspapers printed stories about how pagers help busy people manage time and stress.

Some stories explained how pagers help parents and children call one another for meals and rides. Other stories explained how pagers help parents to call children home from play and help children let working parents know they have arrived home from school.

The campaign was carried out under the banner of the Paging Services Council, a consumer information source operated by Telocator.

Hollywood connection

In addition, Telocator placed advertising in entertainment industry trade publications to offer pagers for use as props in TV and movie productions. Pagers have been made available to key writers and producers to familiar-

ize them with their applications. Contacts were made with screenwriters to encourage them to write positive applications for pagers into their TV and movie scripts.

Now that the initial year of Motorola's sponsorship has ended, the association plans to fund the publicity campaign.

Telocator president Thomas Stroup told the audience the association would like to see private and common carrier paging governed by a common set of rules. Another association goal is for paging licenses to be issued for service to an area, not by transmitter site, emulating the method for cellular mobile telephone system licensing.

Association goals

New Telocator chairman William de Kay of Dial Page, Greenville, SC, outlined his goals for the association in the coming year. He said the goals are based on leveraging the association's past successes:

1) to keep Telocator strong by providing a value worth the members' dues and maintaining the association's financial strength.

2) to help the industry to grow by continuing the publicity campaign for paging and by supporting members' and manufacturers' developments in narrowband and wideband personal communications services.

3) by building on a positive relationship with the FCC.

Telocator and the Cellular Telecommunications Industry Association



Telocator president Thomas Stroup moderates a panel session about wireless communications in 2000.



Telocator chairman William de Kay lists goals for 1993.

(CTIA) are cooperating in a project to rewrite Part 22 of the FCC rules that regulate common carrier mobile services. At one time, the two associations competed for cellular carrier members, and cooperation between them was difficult to achieve.

Indicating the new level of cooperation, CTIA president Thomas Wheeler participated in the trade show's session on the mobile communications industry's future.

Views of the future

Seven panelists exchanged opinions and answered questions from Stroup, who was the moderator, and from audience members.

George Perrin, president of Paging Network, said the \$10/mo. paging customer will continue to offer opportunities for paging companies. "Companies will be able to use their infrastructure and back office to take advantage of other communications service opportunities, too," he said.

Alan Reiter, group executive editor of *Mobile Data Report* newsletter, foresaw the demise of high-end paging services. He said they will give way to palmtop computers with built-in pagers.

Brian Pemberton, president of American Mobile Satellite, said: "I foresee pervasive North American coverage for cellular carriers and SMRs and, by 2000, worldwide compatibility among mobile communications services." (SMRs are specialized mobile radio systems that offer two-way radio and mobile telephone service.)



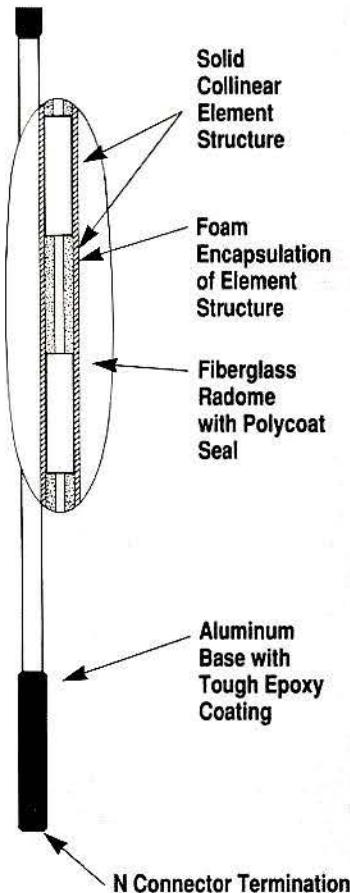
Fleet Call chairman Morgan O'Brien shuns regulatory protection.

David Garrison, president of Skytel, said that equipment cannot be offered at the lowest prices that will allow the greatest mar-

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News

ket penetration until worldwide standards are adopted.

Morgan O'Brien, chairman of Fleet Call, said: "I see dinosaurs roaming the landscape, stepping on themselves and each other," referring to mobile services companies that rely on regulators to protect them from competition. "We [Fleet Call] don't want regulatory protection. It may help in the short run, but it becomes an anchor to be dragged around forever."

O'Brien identified the trend as a continuing obliteration of distinctions among mobile services businesses.

Paging regulation

Speaking to a luncheon audience, FCC commissioner Sherrie Marshall gave operators of large paging systems good news: "The commission has no intention of withholding a decision on



FCC commissioner Sherrie Marshall gives good news to operators of large paging systems.

with the clear understanding that the narrowband issue will proceed on a separate track, if necessary," the commissioner said.

The next Mobile Communications Marketplace is scheduled for Sept. 28-Oct. 1 at the New Orleans Convention Center in New Orleans.

Allied-Signal to divest mobile communications unit

Allied-Signal, Torrance, CA, has decided to sell its Mobile Communications division in Lawrence, KS.

In making the announcement, Allied-Signal said that the Bendix/King Mobile Communications division is a strong, profitable business with substantial growth potential. The company said that it decided to divest the division after a thorough review of the strategic outlook of its core businesses.

Allied-Signal said that it will focus its management and financial resources on its core aerospace businesses.

The investment banking firm of Morgan Stanley, New York, has been retained to market the business unit.

With 1992 revenues of approximately \$36 million, the division designs, manufactures, distributes and supports two-way radio products for the ground communications market.

Repco files for protection from landlord, creditors

Repco, an Orlando, FL-based manufacturer of two-way radios and RF modems, has petitioned the federal court for protection from creditors under Chapter 11 of the Bankruptcy Act.

According to Repco vice president Joanne Kostantinidis, the company was burdened by a headquarters and manufacturing facility several times larger than necessary for current operations. Its landlord would not renegotiate the remaining 15 years of a 25-year lease to the company's satisfaction, so it relocated and asked the court for protection.

Repco sells its products to Aerotron-Repco Sales (ARS), which in turn resells them. The current product line

includes crystal-controlled lowband VHF and highband VHF hand-held two-way radios and modems for sending data and telemetry over radio channels.

"Aerotron" in Aerotron-Repco Sales' name refers to Raleigh, NC-based radio equipment manufacturer AER-Aerotron. ARS, Repco and AER-Aerotron are related companies inasmuch as they are controlled through majority stock positions owned by Atlas Financial Holdings, headed by Andrew Kostantinidis, Joanne Kostantinidis' father.

Repco and ARS are at 2400 Sand Lake Road, Orlando, FL 32809; telephone 407-856-1953.



SMR operators file multiple license applications

By Alan S. Tilles, Esq.

The surge of 800MHz wide-area digital specialized mobile radio (SMR) system applications filed with the FCC continues.

Additional applications have been filed by CenCall for Kansas, Missouri and Oklahoma, in addition to the company's earlier Colorado filing. U.S. Digital has applied to add sites to its earlier Florida application. Johnson Communications has filed applications for Atlanta; Advanced MobileComm for Las Vegas; and Questar for Seattle and Portland, OR.

The new filings come on the heels of an FCC Private Radio Bureau order freezing all additional "short-spacing" not based upon the commission's Part 90 short-spacing chart. The freeze, originally requested by Motorola, is intended to continue until the agency completes a rulemaking that would review standards for granting short-spacing waivers.

There is a consensus within the SMR industry that any short-spacing minimally should meet the 40dB μ /22dB μ desired-to-undesired signal overlap analysis originally suggested by the National Association of Business and Educational Radio (NABER) and the American Mobile Telecommunications Association (AMTA).

Nonetheless, industry participants have expressed concern that some of the wide-area filings have cited a 40dB μ /30dB μ overlap analysis. It is unclear whether the FCC will grant the waivers requested on the basis of the 40dB μ /30dB μ overlap analysis. Still, the commission clearly is troubled by the wide-area waiver requests that seek to expand service footprints into areas not currently served.

The numerous filings have caused many SMR operators to re-evaluate their business plans. The changing SMR landscape has accelerated some plans, changed others and appears to be attracting the interests of larger

players. The resulting shape of the SMR business remains to be seen.

License gap

Apparently, word that the FCC eliminated SMR end-user licensing did not reach the agency's field office employees as quickly as it reached SMR system operators.

Shortly after the new rules eliminating the licensing requirement became effective, FCC Field Operations Bureau employees in at least two offices approached SMR end-users and requested copies of their licenses. When the SMR system operators involved found out, they contacted the FCC's Washington headquarters and asked that the field offices be notified that end-user licenses are not required.

SMR licensing scams

Several business entities have been marketing a so-called third cellular license opportunity to the general public, even through broadcast radio commercial announcements.

The marketers describe the SMR business in terms that in some cases mislead anyone unfamiliar with the business. For example, in one case, statements lead the unwary applicant to believe that the FCC currently is accepting applications for 900MHz SMR systems. Other statements incorrectly indicate that the application is guaranteed a license for a location somewhere in the United States.

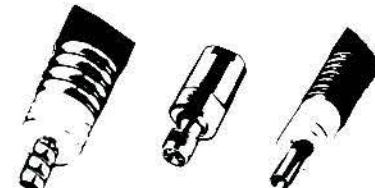
The FCC has reacted to these misleading presentations by issuing a consumer alert. The alert seeks to correct the following *misimpressions*:

- (1) The SMR service is a recent development.
- (2) SMR licenses are cellular mobile telephone licenses.
- (3) The FCC currently is accepting 900MHz SMR applications.
- (4) The 800MHz SMR frequencies are readily available in large urban areas.
- (5) An SMR license for an unconstructed system may be sold.
- (6) There is a fee for obtaining a copy of FCC Form 574.

Tilles, MRT's regulatory consultant, is a partner in the law firm of Meyer, Faller, Weisman and Rosenberg, P.C., Washington, DC.



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Readers' choice

Of all the new products and services in the May 1992 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them: Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

Portable handles voice encryption

Model M-PA Voice Guard portable radio from **Ericsson GE Mobile Communications** suits conventional uses and GE's digital access communication system (DACS). The hand-held with voice encryption comes in select, scan or systems models. The radio is available in VHF and UHF bands in the conventional version and in both UHF and 800MHz bands in the DACS dual-mode versions.

Circle (500) on Fast Fact Card

VHF, UHF portables provide 5W output



The SH505FDT VHF portable and model SH405FDT UHF portable come with a 600mAh battery and offer 5W RF output. The synthesized portables include CTCSS, power save function, keyboard light and keyboard lock. Channel capacity is 10 to 60, and the portables are available from **Shinwa Communications of America**.

Circle (501) on Fast Fact Card

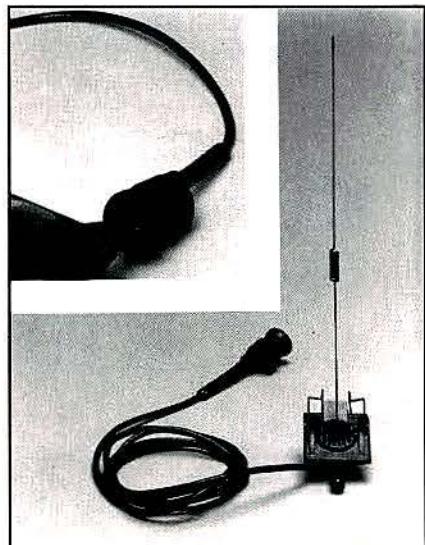
Programmable desktop station delivers 128 channels



The Spectra field-programmable desktop station from **Motorola** includes 128 channels for use in allotted frequencies in VHF, UHF, 800MHz and 900MHz bands. The unit features call alert and private conversation functions. Trunked versions can access 240 talk groups and multiple conventional channels.

Circle (502) on Fast Fact Card

Clip-on antenna to improve vehicular hand-held reception



The clip-on coupler antenna from **Mobile Mark** works with the Motorola Micro TAC cellular hand-held for better in-vehicle performance. The antenna slides on and off a vehicle door's window, and the whip is outside the car for better reception.

Circle (300) on Fast Fact Card

GPS-based location sensor locates vehicles

Placer GPS 300 is a GPS-based location sensor that is specifically designed for vehicle applications. The 6-channel receiver/antenna installs on the top of the vehicle and measures 4.5" x 6.4" x 1.6". The unit from **Trimble Navigation** reports reliable positions in less than 30 seconds and can reacquire vehicle positions in 3 seconds when GPS satellite signals are temporarily blocked by tall buildings.

Circle (309) on Fast Fact Card



Wireless mobile systems connect mobile workforces

The DataTAC system from **Motorola** extends information systems and networking resources to mobile workforces in the field. It includes intelligent and rugged user devices, a set of high-message throughout infrastructure products, and a core radio data technology that delivers higher data traffic volumes over land mobile radio channels than currently available systems. DataTAC supports traditional mobile applications such as computer-aided dispatch, database inquiry and vehicle fleet management; and provides for future applications

for enhanced report writing, E-mail, graphics and imaging. Most DataTAC products support the radio channel protocols of installed systems, allowing new products to be introduced to these systems over a period of time.

Components include intelligent mobile terminals and workstations, portable terminals and computers, mobile radio modems, pen-based computers, portable radio modems with built-in two-way paging and data communications network products for interfaces to host applications.

Circle (325) on Fast Fact Card

Trunked radio works with LTR-compatible units

Model 70-9020 two-way FM mobile radio is compatible with any 800MHz trunked system using the LTR protocol. The 15W under-dash mobiles can be programmed for up to 10 systems, trunked or conventional in any combination. The **Midland** mobile is programmable for two trunked priority call levels and for transpond, which automatically acknowledges in-range trunked units to the caller.



Circle (314) on Fast Fact Card

Computer program anticipates antenna pattern distortion

The Antenna Pattern Module of the Terrain Analysis Package is a computer program that predicts what happens to the antenna pattern depending on the mounting orientation on the tower, the distance from the tower face or leg, tower face dimension, tower shape, antenna gain and transmitted frequency. The program from **SoftWright** calculates, tabulates and plots the anticipated antenna pattern with the particular mounting information proposed.

Circle (318) on Fast Fact Card

Mic offers DTMF encoding



CES' heavy-duty manual dialing DTMF encoding microphone features a backlit, tactile alphanumeric keypad. Model 805 is the manual hardened version of the 810 sealed programmable microphone and is designed to meet MIL-STD-810 for shock, vibration, temperature extremes and rain.

Circle (305) on Fast Fact Card

Radio tower monitoring system implements nationwide service

LODA (Location Data Systems) is implementing a nationwide radio tower monitoring system. The R-2000FS monitors events at remote radio tower sites and reports alarms and malfunctions on an around-the-clock basis to LODA Central. Within minutes of a tower light failure, an alarm is transmitted to LODA Central, which

makes prompt notification to the appropriate FAA Flight Service Station and the tower's customer. Features include a complete back-up light controller, internal verification of photocell operation, FalseSafe confirmation of alarms, confirmation of proper flash rates and sequencing, and battery back-up.

Circle (321) on Fast Fact Card

If you ever DF from 25 to 1000 MHz and need to do it unobtrusively, you'll want the TD-L8630P-II



Hardly anyone will notice.

This compact unit from Simrad/Taiyo provides radio direction finding capabilities on all frequencies from 25 to 1000 MHz (also 1.6 to 25 MHz with optional antenna). Easily portable, the unit comes with a camera bag sized case with shoulder strap. The unit also operates as a monitor receiver from 100 kHz to 2 GHz. A hand-held antenna with pistol grip is supplied standard, or

for covert operation a special flat antenna is mounted directly on the main unit. Bearing is indicated by a circular LED display and a meter shows field strength. Spare rechargeable battery,



charger and carrying case are included. Police, defense, security, and other intelligence operators no longer have to worry about jammed communications. If you need to locate interference or other RF source, the 8630P-II is the tool for you. And hardly anyone will notice. Send for complete information today, or call toll-free 1-800-426-5565. Simrad. A name you can trust.

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Circle (50) on Fast Fact Card

New products

Radio fits in shirt pocket

Available in UHF and VHF, model HX241 is a 16-channel radio that is compact enough to fit in a shirt pocket. The radio from **Standard Communications** is equipped with CTCSS tones, DCS codes, power output of 1.5W or 4W and an LCD readout with an operator selectable scan function.

Circle (315) on Fast Fact Card



Software offers site plotting, composite coverage prediction

MSITE version 1.0 offers comprehensive composite coverage prediction and plotting for multiple antenna sites or facilities. The software offered by **EDX Engineering** plots composite maps (for as many as 16 sites), shadow, field strength, receive power level, interference or signal ratio, and most likely server.

Circle (311) on Fast Fact Card

Software applications include satellite, microwave comms

The **EEsoft** Series IV software is a new generation of Unix-based electronic design automation (EDA) for high-frequency analog circuit and system design. The software incorporates X-Windows and Motif graphical user interface. Applications include the design of cellular and personal communications (PCN) system, satellite and microwave communications, high-speed computer interfaces, and radar and electronic defense systems.

Circle (313) on Fast Fact Card

Connectors turn at 90° angle



T and L adaptors for 7-16 coaxial connectors are available when low intermodulation products are desired or when the routing of the transmission line must turn 90° in a space too small to accommodate normal cable bands. The connectors from **Huber+Suhner** have reflection factors as low as .02 max. at 5.5GHz.

Circle (319) on Fast Fact Card

Miniature encoder offers 15 paging codes

The PE-15 is a miniature sub-assembly encoder capable of sending 15 separate codes in the POCSAG (RPC-1) format. The PE-15 is intended for operators of local "in-house" radio systems wishing to signal tone-only pagers. The 15 available codes may be used to activate as many as four distinct alert tones on each pager, 15 individual pagers or any combination. The paging encoder from **Communications Specialists** is factory programmed to specific address codes or may be field programmed via an available keypad.

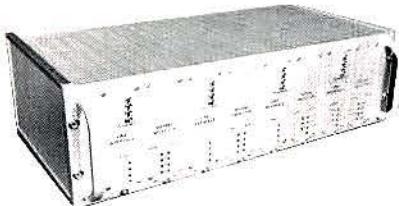
Circle (308) on Fast Fact Card

Power module converts ac to dc

AC-Plus power module from **CSC Power Systems** converts 110Vac to 12Vdc for two-way radios and other devices operating through a 110V power supply. The module incorporates an internal 7Ah battery with automatic changeover, charging, filtering and regulation.

Circle (303) on Fast Fact Card

SIGNAL-TO-NOISE Voting Comparator



Improve coverage by adding receivers

- Expandable to 32 Channels
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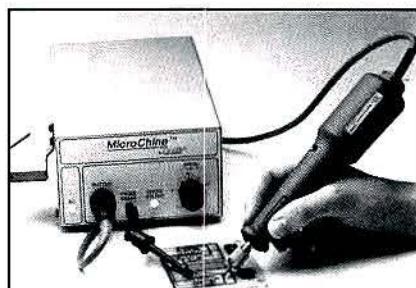
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Circle (62) on Fast Fact Card

Machining system repairs printed circuit boards



MicroChime is a lightweight, variable-speed miniature machining system designed to repair and modify circuit boards. The handpiece has a non-chalking static-dissipative plastic housing for static-free operation, and its motor provides measured acceleration to selected speeds from 2,500 RPM to 10,000 RPM. The unit from **Pace** meets or exceeds military and civilian safety requirements.

Circle (317) on Fast Fact Card

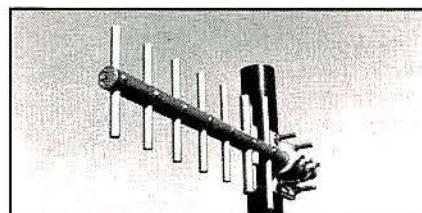
Multi-tasking radio test set cuts test times in half

Combining more than 30 high performance instrument functions with fast multiple measurement capability in a compact, lightweight package, the 2965 from **Marconi** is a multi-tasking radio test set. Speed and high accuracy provide fast automated measurements that cut typical radio test times in half. Key RF instrument functions include full-span high dynamic-range spectrum analyzer with tracking generator; accurate RF power meter; storage oscillo-

scope; and fast switching RF signal generator. Audio capabilities include FTT audio analyzer and three independent audio generators. Measurement functions range from a fast sampling 500kHz digital storage oscilloscope (DSO) to a built-in multimeter for measuring resistance, ac/dc voltage, and current. The 2965 internally supports all analog-cellular and trunking standards.

Circle (326) on Fast Fact Card

Yagi antenna covers trunking, cellular band

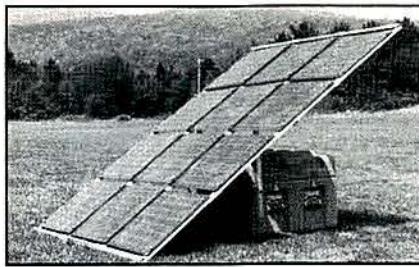


The TY-840/TY-860 is a seven-element yagi that has 10dBd of gain. The TY-840 covers the broadband range from 806MHz to 869MHz and the TY-860 covers the cellular band from 824MHz to 894MHz. The Scala antennas are anodized and include stainless steel fasteners and u-bolts to prevent corrosion.

Circle (323) on Fast Fact Card

Portable solar generators suit remote locations

The Micro PowerPak series of portable solar electric generators support remote field applications with electric loads from 100W to 2,000W per day. Features include no fuel required, silent operation, low maintenance, low EMI, rapid deployment, compact and portable. The units from **Northern Power Systems** can power ac and dc applications and are classified by peak solar capacity (72W to 360W).



Circle (304) on Fast Fact Card

UHF transceiver boasts 5W

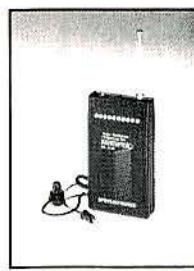
The EasyTalk UHF-50 is a hand-held two-way radio that weighs 16 ounces. The four-channel transceiver comes with a flexible rubber duck antenna with a BNC connector, an ac/dc wall charger, a stainless steel belt clip, carrying case and an 11V NiCd rechargeable battery pack. The radio from **Nady Systems** operates in the 450MHz-to-470MHz band.



Circle (316) on Fast Fact Card

Communications device locates stuck transmitters

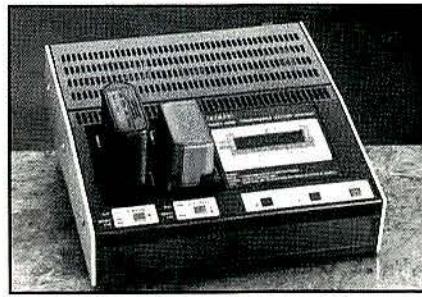
The R20 AM Interceptor checks two-way radios for RF output; makes RF signal strength measurements; locates stuck transmitters; and listens to any AM modulated signal including CB and aircraft two-way transmissions. The ten LED bargraph provides a relative signal level display using 3dB steps for all RF signals detected. The unit from **Optoelectronics** covers 0.5MHz to 2.5GHz frequencies.



Circle (322) on Fast Fact Card

Battery analyzer features interface for programming caps, cables

The **Cadex** C3000 battery analyzer features a menu-driven interface for programming the unit's battery cups and cables. The C3000 services NiCds, nickel metal hydride and lead-acid batteries. Weak batteries are identified and automatically reconditioned; good batteries are exercised to maintain peak performance. With the printer option, battery service reports and labels can be generated; an RS232 port allows interfacing to a computer.



Circle (310) on Fast Fact Card

Consoles mount equipment together

Four radio control heads, siren and light controllers and scanners are mounted into the face plate adapters that secure into the Command Console. Equipment and cables are secure inside the console, yet accessible for service. The consoles by **Troy Products** are available for the Chevy Caprice and Ford Crown Victoria. Flat-floor adaptors are available for fire equipment, vans and 4-wheel drive vehicles. The consoles are 11-gallon steel-coated with non-reflective black wrinkle epoxy finish.

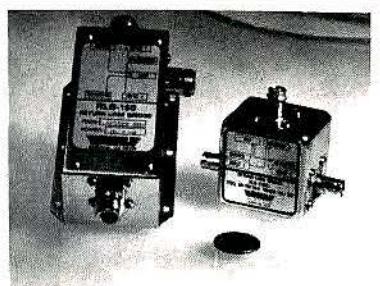


Circle (320) on Fast Fact Card

SMA connector design fits superflexible cables

The 41ASWS SMA male and 41ASNS SMA female bulkhead connector fit 1/4-inch superflexible cables from **Andrew**.

Circle (328) on Fast Fact Card



Return Loss Bridges

RLB150 bridges are a high accuracy low cost solution to SWR measurements. They can be used with spectrum analyzer/tracking generator for swept SWR measurements. EAGLE RLBs have these features:

- Frequencies: .04 Mhz to 1.0 GHz
- RF reflected port
- High Power rating: Five watts
- Rugged construction
- High Directivity: up to 45 dB

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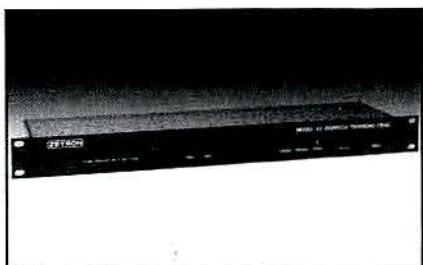
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Circle (63) on Fast Fact Card

New products

Repeater controller boasts smart channel allocation

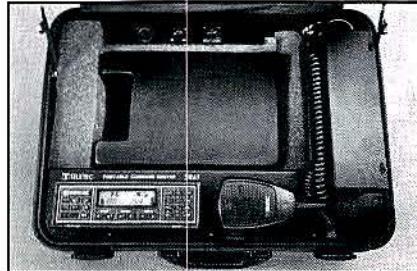


Circle (324) on Fast Fact Card

The Model 42 converts any digital-capable repeater into a fully featured, dispatch-only LTR trunking channel. It is equipped with a repeater with LTR logic-processing capabilities, subscriber validation, airtime accumulation, automatic program cloning and smart channel allocation. The Zetron unit is intended for dispatch (radio-to-radio) calls, instead of interconnect (radio-to-telephone) calls.

Communications command center boasts location flexibility

The Swat1000 and Swat2000 suitcase communications command center contains a 110VAC power supply, rechargeable battery and charger. The Teletec unit can switch the duplexer in and out of the antenna path, allowing some channels to operate as a repeater, while others operate simplex anywhere in the frequency band. Other features include 1,024 channels in 32 groups of 32 channels; 3 levels of priority scan per group; five operating modes: manual, manual with priority, scan, scan with priority and free channel access; digital or analog encryption option; and phone patch for direct access to



the PSTN using any radio with a DTMF encoder.

Circle (307) on Fast Fact Card

Dash-mount UHF mobile boasts 114 channels



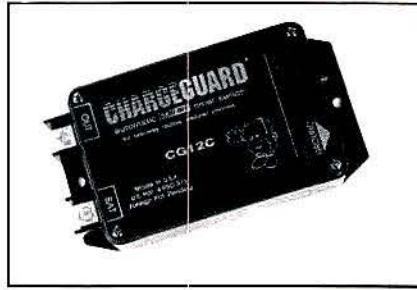
Circle (261) on Fast Fact Card

The EMV 499 0A UHF mobile from **Bendix/King** operates from 10W to 40W and is housed in a die-cast frame. The radio includes 114 channels. It may be programmed to operate in the 403MHz-to-470MHz bands without degradation in specification. The mobile has an eight-character alphanumeric display and meets military specs 810C, D and E. It meets EIA and U.S. Forestry Service specs for vibration and shock.

Battery-saving device switches equipment on, off

The ChargeGuard device automatically switches equipment such as two-way radios, mobile phones, PCs and mobile data terminals off and on at programmable intervals. The **ChargeGuard** unit is programmable from 15 minutes to 15 hours. The unit offers equipment protection, as well, with low-voltage disconnect, high-voltage disconnect and reverse polarity protection features. The device is available in 12V and 24V models.

Circle (301) on Fast Fact Card



Leg ground strap features stainless steel clamps

Lightning Master's tower leg ground strap provides economical, low impedance grounding for virtually any tower. The straps are constructed of copper and are plated to assure minimum dissimilar metal corrosion problems.

Circle (302) on Fast Fact Card



Software computes antenna characteristics

Software from **Austin Antenna** computes characteristics for short-loaded dipoles, dualband trap dipoles and calculates element frequency scaling. Sections include wire gauge tables; dielectric constants; drill sizes; taps, tap drills and thread clearance; metric and units conversion; windload calculations for vertical antennas; and an antenna gain calculator for any vertical antenna aperture. The software is IBM compatible and requires VGA graphics.

Circle (306) on Fast Fact Card

Vari-Tilt antennas provide expanded coverage

The ASP-977 series of omnidirectional base station antennas offers **Antenna Specialists' field-adjustable Variable Electrical Beamtilt (VEB)**. The ASPA977 (806MHz to 869MHz) and ASPJ977 (872MHz to 960MHz) provide coverage for TACS, ETACS, GSM, paging and 800MHz/900MHz trunking systems. The beamtilt tuning scheme permits accurate adjustments from -3° to -8° below the horizon before or after the antenna is installed.

Circle (312) on Fast Fact Card

Software provides data management, real time reception

Version 1.3 from **TSR Technologies** provides real time traffic reception and data management on its Cellscope and Pagetracker system. The software operates on any AMPS or ETACS cellular system, or on any POCSAG, Golay or NEC paging system.

Circle (327) on Fast Fact Card

Catalog lists RF power measuring equipment

The 50th anniversary catalog from **Bird Electronic** contains detailed descriptions and specifications with many photos of RF power measuring equipment and accessories. Along

Circle (403) on Fast Fact Card

with its line of wattmeters, the catalog includes selections of RF power calorimeters, plug-in elements, line sections, QC connectors, RF loads and attenuators.

Catalog details test equipment

A catalog detailing portable and benchtop test and measurement instruments is available from **Bel Merit**. It is geared toward the engineer, student, technician or hobbyist who tests, repairs or assembles electronic or electrical equipment. Highlighted in the catalog are full multifunction digital multimeters with holster, digital clamp-on current meters, bench instruments, non-contact voltage detectors, electrical voltage testers, continuity checkers, ac circuit analyzers and oscilloscope probes.

Circle (402) on Fast Fact Card

Catalog describes BETRS equipment

Telephone utilities can take advantage of the newly created wireless exchange system using the 454MHz to 460MHz band. A catalog from **Scala** exclusively for the Basic Exchange

Telephone Radio Service (BETRS) incorporates antennas for subscribers, central sites, mounting accessories and technical information.

Circle (404) on Fast Fact Card

Brochure describes AVL products

A brochure from **Position Technology** features its line of AVL products. It includes outputs for different types of transmitters, optional receiver/transmitters and other optional equipment.

Circle (406) on Fast Fact Card

Catalog lists signaling equipment

A color, user-friendly catalog shows **Selectone**'s comprehensive product line of tone signaling and remote control accessories. Featured products include CTCSS, two-tone sequential, DTMF and burst tone signaling, remote controls, shared repeater panels, automatic number identification (ANI) and voice encryption. Included is a section describing products that will be introduced in the near future.

Circle (407) on Fast Fact Card

Brochure describes circulators and isolators

A six-page brochure from **Tx Rx Systems** describes ferrite circulators and isolators for the 118MHz-to-960MHz range, as well as RF loads and harmonic filters.

All forward and reflected power ratings are based on continuous duty conditions to preclude uncertainties arising from unspecified duty cycles or design conditions. Explicit RF load specifications include resistor element power rating, heatsink surface area and power density.

Circle (401) on Fast Fact Card

The ULTIMATE PROTECTION...

NOBODY...but NOBODY
beats the quality
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LEATHERSMITH's specially-developed, steer
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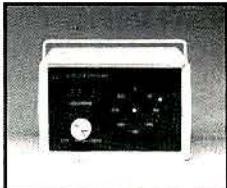
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INTERFERENCE LOCATION



- ★ 50 to 1000 MHz
- ★ Stuck Microphones
- ★ Cable TV Leaks
- ★ Jammed Repeaters & Cell Sites



New Technology (patented) converts any VHF or UHF FM receiver into a sensitive Doppler shift radio direction finder. Simply plug into receiver's antenna and external speaker jacks. Models available with computer interface, synthesized speech, fixed site or mobile - 50 MHz to 1 GHz. Call or write for details.

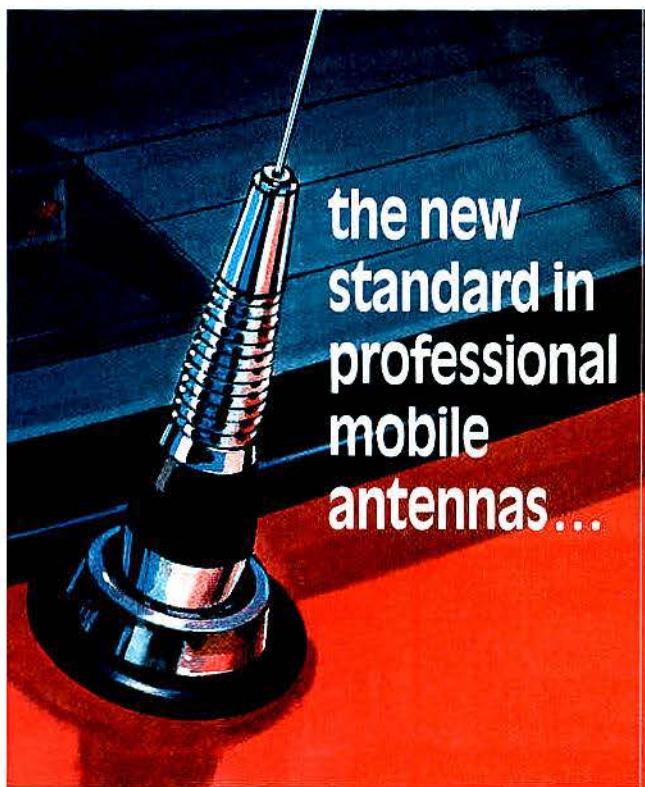


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No more compromises with quality, performance or value. You get it all with our PRO-5000™ VHF and UHF professional mobile antennas. All new A/S design from the ground-plane up for optimum reliability.

- **Triple O-ring seals** — runs rings around others for superior protection from water and other contaminants.
- **100% factory-tuned and locked coils** for long-term frequency stability.
- **All internal connections** soldered or press-fit for electrical integrity.
- **Clean, contemporary, functional design**
- **Stainless steel whips**: VHF models DURA-CON® plated for highest conductivity.
- **Power rated 150 Watts; VSWR less than 1.5:1; Gain 3 dB (VHF); 3 dB or 5 dB (UHF)**.

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Feedback

'Not enough frequencies available'

According to 85.7% of the respondents to the June 1992 "What Do You Think?" questionnaire, land mobile radio frequencies are too crowded. Readers' responses include:

- "Lack of spectrum and poor prior coordination."
- "Limited spectrum for number of users. It is not just distance apart, it's power!"
- "No room to expand."
- "Too many users on each channel."

Dealers contributed the majority of responses received in this survey, with 42.9%. Other participants include:

Public safety and government	17.1%
Business and industrial users	14.3%
Service providers	14.3%
Transportation	2.9%
Other/No response	8.6%

85.7% of the respondents operate on conventional mobile radio frequencies. The following statistics show other frequencies used by the readers (multiple responses add up to more than 100%):

Conventional mobile radio	85.7%
SMR	45.7%
PCP paging	37.1%
Mobile data	20.0%
Cellular	17.1%
RCC paging	14.3%
Automatic vehicle location	11.4%
Marine	2.9%
Other	20.0%

Opinions vary on how regulation can relieve congestion. Readers' responses include:

- "Better enforcement of existing rules."
- "Better frequency coordination."
- "Re-instate FCC power to regulate and disband the middlemen (i.e. NABER)."
- "Better monitoring."
- "Complete refarming."
- "Regulations that encourage new modulation technologies (i.e. spread spectrum; ACSB)."
- "Stiffer enforcement of basic rules of enforcement."

Digital and narrowband technologies are suggested by readers as technologies they believe can improve frequency use. Other responses include:

- "ACSB."
- "Convert many existing 150MHz, 450MHz and 460MHz repeaters to trunked mode."
- "Making radios more spectrum efficient. Pushing more 12.5kHz and 5kHz spectrum technology."
- "Time domain multiplexing. The telecommunications industry has been using this technology for 20+ years (T1). It's time radio adopted this technology."
- "Open up more spectrum to conventional mobile radio users."

Ron Nessen departs Westwood One, Washington, DC, the parent company of the Mutual Broadcasting System and the NBC Radio Network, as vice president of news to become first vice president of public affairs and communications at Cellular Telecommunications Industry Association, Washington, DC.

Ron Cooper exits General Electric, Lynchburg, VA, as president of Consulting Services, a GE subsidiary, to join PRC, McLean, VA, as president of PRC's Commercial & International group.

Changes at Unipage, DeSoto, TX, stemming from the sale of the company to Motorola, Schaumburg, IL:

Patrick R. Koons exits Teknekron Infoswitch, Dallas, to become president of Unipage, replacing company co-founder **Tim Minter**, who continues as a Unipage consultant.

Company co-founder **R. Gene "Bud" Forester** steps down as vice president and continues as a Unipage consultant.

Joe Krystofik exits SGS Thomson, Dallas, as business unit manager and joins Unipage as vice president of marketing.

Chuck Rauch, a resource manager for transmitter design at Motorola in Schaumburg, moves to Unipage as vice president of operations.

Jeff Starling, manager of manufacturing and hardware development engineering for paging terminals at Motorola's Boynton Beach, FL, facility, moves to Unipage to become manufacturing operations manager.

Bob Treasure exits Beep California, Scottsdale, AZ, as president and becomes area manager for western states at Unipage.

Mark Middlekamp departs Cincinnati Bell Telephone, Cincinnati, as product manager of paging services to join Unipage as systems marketing representative.

Susan Lee Austin, a co-founder of SBT, Allentown, PA, joins Unipage as marketing assistant.

Changes at The Antenna Company, Broadview, IL:

Steven Maher, director of training, moves up to midwest regional sales manager.

Christina Seiler, western regional manager, becomes north central regional manager.

Betsy Popp, midwest regional manager, moves to western regional manager.

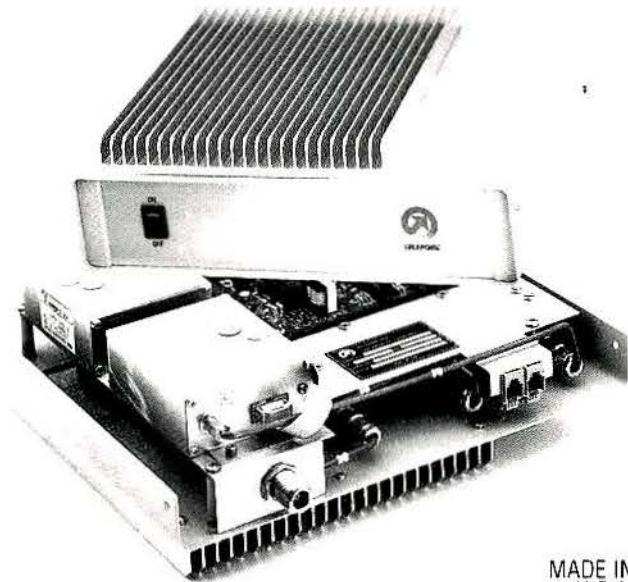
Changes at Multiplier, Mt. Kisco, NY:

Rich Simels leaves V Band, Elmsford, NY, as director of sales to become national sales manager for Multiplier.

Craig Hindley leaves Antenna Products, Aylesbury, Buckinghamshire, England, as northern sales manager to head sales and marketing efforts in behalf of Multiplier Ltd., Hursted, England, the company's U.K. sales and distribution facility.

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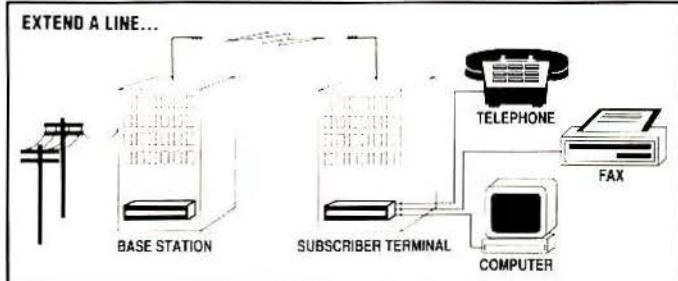


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L etters to the editor

Combining antennas:

The July article "Combining and Phasing Land Mobile Base Antennas" by Brian Henderson, P.Eng., was quite informative, although several important bits of information were left out.

First, when phasing antennas together, it is important to keep their polarities the same.

For example, when using two yagi antennas, make sure both antenna impedance matching sections (the grounded side of the driven element or gamma match) are aligned in the same direction. It does not matter in which direction they are aligned as long as the direction is the same.

When phasing larger antennas, such as four-bay arrays, and one antenna is turned upside down so the feedpoint is in the center between the two antennas, exactly 0.5-wavelength of feedline must be added to one side of the matching harness. This keeps the antennas in phase. Without the extra feedline, the signals are 180° out of phase, and the signals they broadcast cancel one another at the fringe of the coverage area.

Second, antennas must be placed in the same vertical or horizontal plane to achieve a 3dB gain over the original antenna pattern.

Failure to keep the antennas in the same plane alters the antennas' radiation pattern by signal phase cancellation.

For example, adding a second antenna on the opposite side of a tower from a previously side-mounted antenna to reduce the null caused by the tower may create another null in a different direction. Computer design programs can help to design a system carefully to avoid costly pitfalls. In addition, many antenna manufacturers offer free advice.

Mr. Henderson describes how to use two quarter-wavelength sections of 75Ω coax to phase two 50Ω antennas to one 50Ω feedline. A variation of this phasing harness uses a quarterwave stub of 62.5Ω coax on each end of a 75Ω feedline to make the feedline and antenna look like 50Ω to the transmitter.

I have used these stubs with a 0.75-inch 75Ω CATV hardline with good results. One sometimes can obtain con-

tinuous lengths of coax as long as several hundred feet as remnants from spools just for the asking.

There are many good books on antennas and feedline theory. One I recommend is *The ARRL Antenna Handbook*. It often is for sale at hamfests and is available from the American Radio Relay League, Newington, CT.

The book has more information than anyone would want to know. It is written in a manner that most technical people understand.

John D. Smith
Shop Manager

Gunby Communications
Leesville, SC

Brian Henderson's response to John Smith's letter is too long to include in this month's letters column. It will appear next month.

—DB

The toughest problem facing me on the job is:

- to have communication from work site to workshop and from work site to my residence.

Cris Raguro

Technician

Sharikat Fanniya Omaniyah
Muscat, Oman

The two toughest problems facing me on the job are:

- keeping up with rapidly changing technology.
- finding parts for older equipment at a reasonable cost.

T.R. Swisher Jr.

Owner

Image Concepts
Columbus, OH

The two toughest problems facing me on the job are:

- adapting 800MHz trunking radios to underground mines.
- trying to find trunking mobiles and portables that have a decent size and volume.

Jean-Paul Saindon
Program Director

Noranda Technology Centre
Point-Claire, Quebec



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The journal of mobile communications technology

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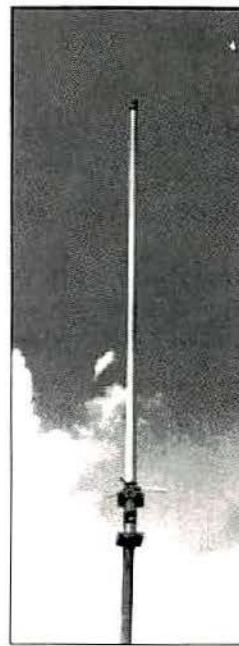
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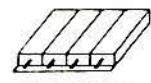
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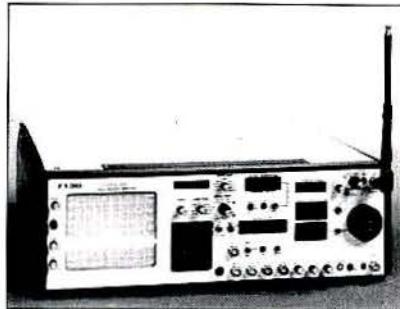
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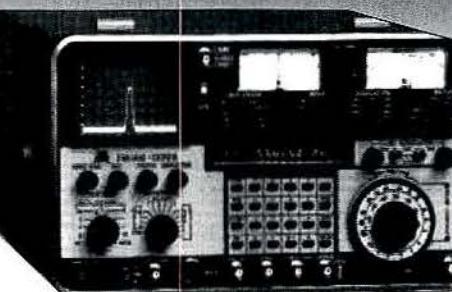
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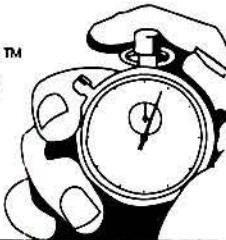
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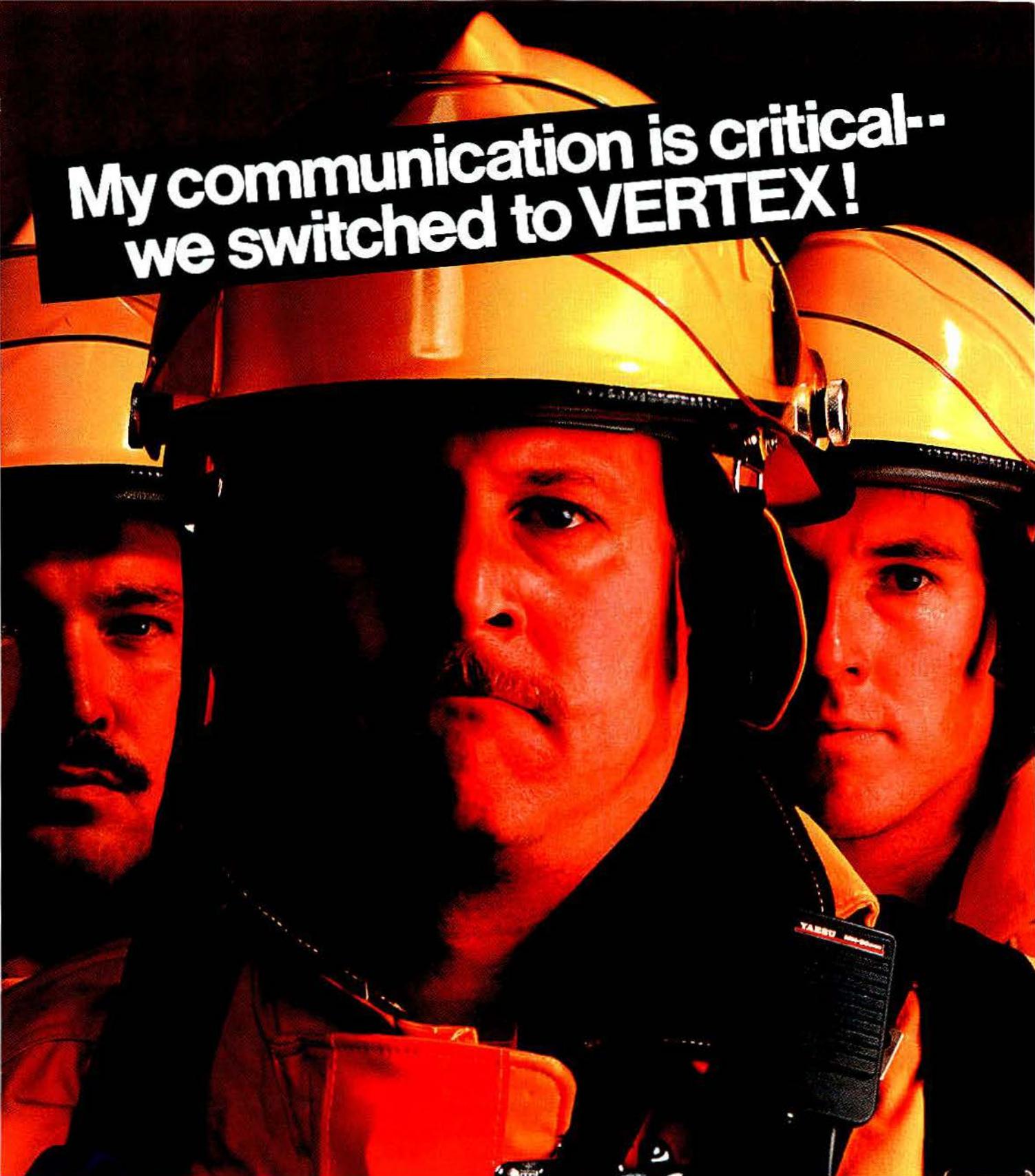
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